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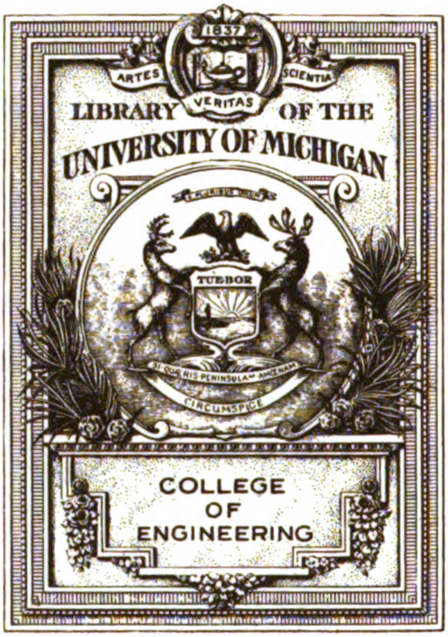

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# CONCRETE
# AND
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## INDEX

PAGE

**BOOKS, NEW:**
Analysis of Statically Indeterminate Structures by the Slope Deflection Method .. .. 139
Arrol's Bridge and Structural Engineer's Handbook. By Sam Hunter .. .. .. .. 709
Cement. By Bertram Blount .. .. .. 777
Chemical Analysis of Steel Works Materials. By Fred Ibbotson .. .. .. .. .. 844
Concrete Diary and Pocket Book, A .. .. 503
Conference on Housing in France .. .. 503
Concrete for House, Farm and Estate. By Fred Ballard .. .. .. .. .. .. 778
Foundations for Machinery. By Henry Adams .. 427
How to Estimate. By John T. Rea .. .. 709
Industrial Administration .. .. .. .. 779
Laxton's Builders' Price Book .. .. .. 428
Mathematics for Engineers. W. N. Rose .. 427
Modern Roads. By H. Percy Boulnois .. .. 139
New Standard Building Prices. By T. E. Coleman .. .. .. .. .. .. 428
Practical Design of Plate Girder Bridges. By H. H. Bird .. .. .. .. .. .. .. 844
Principles of Reinforced Concrete Construction. Turneaure and Maurer .. .. .. .. 650
Retaining Walls: Their Design and Construction. By Geo. Passwell, C.E. .. .. .. .. 709
Slide Rules and How to Use Them. By Thos. Jackson .. .. .. .. .. .. .. 844
Spon's Architects' and Builders' Pocket Book .. 428
Stresses in Hooks and other Curved Beams .. 575
Stresses in Structural Steel Angles .. .. .. 427
Structural Drafting and the Design of Details. By Carlton Thomas Bishop .. .. .. .. 650
Structural Steelwork. By E. G. Beck .. .. 214
Studio Year Book of Decorative Art, 1920 .. 575
Symbols. Mnemonic Notation .. .. .. 213
Useful Data on Reinforced Concrete Buildings .. 428
Waterproofing Engineering. By Joseph Ross .. 710
Who's Who in Engineering. By John Ed. Sears 778

**CONSTRUCTIONAL WORK:**
Adaptability of Reinforced Concrete, The .. 464
Alhambra Theatre, Valparaiso, Chile .. .. 613
Arch Span at Minneapolis .. .. .. .. 276
Ash Receivers, Concrete .. .. .. .. 117
Blocks for Lining Reservoirs, Concrete .. .. 768
Bunkers and Water Towers, Reinforced Concrete .. .. .. .. .. .. .. 33
Chile, Reinforced Concrete in .. .. .. 227
Coke Bunkers, Northampton Gas Light Co. .. 791
Cooling Tower Tank, An interesting .. .. 723
Dalmarnock Power Station, Glasgow .. ..7, 725
Freight Car, The First Reinforced Concrete .. 108
Grain Silo, King George Dock, Hull, The .. 75
Joiners' Shop for Messrs. Craig, Taylor & Co., Ltd., New .. .. .. .. .. .. 464
King George Dock, Hull, The Grain Silo .. .. 75
Mill at Heckmondwike, New Reinforced Concrete 789
Oil Tank for Panama Canal, Large Concrete .. 277
Quay Wall in Reinforced Concrete Piles and Sheet Piles at Kenitra, Morocco .. .. .. 663
Reinforced Concrete Work on the Continent .. 691
Seccondee, Gold Coast, The Water Supply of .. 303
Selfridge's New Building .. .. .. .. 155
Some Reinforced Concrete Structures in Australia .. .. .. .. .. .. 608, 677
Summerhill Bridge, Dublin, Renewal of .. .. 484
Swedish Concrete Bridge, A.. .. .. .. 631
Tanks at Toconce .. .. .. .. .. 227
1,000-Ton Elevated Coal Bunker, A New .. .. 542
U.S. Army Supply Bases, Concrete Work at .. 445
Use of Concrete in the Netherlands .. .. 620
Water Supply of Seccondee, Gold Coast.. .. 303
Whitby Harbour Extension Works. By James Mitchell, M.Inst.C.E. .. .. .. .. 517

**EDITORIALS:**
American Concrete Institute, The .. .. 225
Approved Methods of Construction .. .. 513
Building Trades Exhibition, The .. .. .. 299
Coke Breeze Concrete .. .. .. .. 514
Concrete and Luxury Building .. .. .. 722
Concrete Dwellings and the Fire Hazard .. .. 412
Concrete Institute, The .. .. .. ..3, 444
Concrete Roads and Transport Costs .. .. 443
Concrete Products, The Market for .. .. 226
Conditions in the Building Industry .. .. 588
Consistency of Concrete for Roadwork, The .. 515
Elliptical Vaulting as a Factor in Architecture .. 73
Experiments with Thin Walls .. .. .. 587
Fineness of Cement, The .. .. .. .. 721
Fire Resistance of Concrete, The .. .. .. 151
Flat Slab Design .. .. .. .. .. 658
Future of Concrete, The .. .. .. .. 301
Housing Bonds .. .. .. .. .. 367
House Construction, Concrete for .. .. .. 657
Industrial Research .. .. .. .. .. 787
Jointing Iron Water Pipes with Cement .. .. 661
London School Buildings .. .. .. .. 590
Recent Notes on Concrete Ships .. .. .. 302
Road Construction in America .. .. .. 515
Road Development .. .. .. .. .. 787
Road Transport Congress and Concrete Roads, The .. .. .. .. .. .. .. 1
Safety First .. .. .. .. .. .. 368
Skilled Supervision in Concrete Work, The Importance of .. .. .. .. .. .. 153
Special Methods of Cottage Construction .. .. 370
Standard Method of Measurement for Concrete Work, A .. .. .. .. .. .. 441
Standard Specification for Reinforced Concrete Work .. .. .. .. .. .. 661
Tests of Concrete Mixtures .. .. .. 660
Time Factor in Roadmaking, The .. .. 788
Village Signs .. .. .. .. .. .. 722

**GENERAL:**
Bridge Construction in Reinforced Concrete .. 336
Building Trades Exhibition, The .. .. .. 325
Cement Notes .. .. .. .. .. 834
Civil Engineer's Impression of America, A .. 625
Concreting in Cold Weather .. .. .. 821
Concrete Institute, The. Monthly Notes 475, 561, 603, (See also Memoranda) 684, 748, 804, 806
Concrete Piles (Wilhelmi) .. .. .. .. 760
Correspondence .. .. .. 502, 509, 711, 845
Design for a Water Tower. By Frank N. Heaven 182
Erecting Tower for Concrete Work .. .. 728
Gravity Distributing Plant for Concrete Work .. 573
Housing Exhibition at Olympia .. .. .. 193
Hume Pipe, The .. .. .. .. .. 640
Largest Pile Driver in the World, The .. .. 570
Light Aggregate for Concrete Buildings .. .. 763
Liner Concrete Block-making Machine, The .. 842
Metaforms .. .. .. .. .. .. 62
Metallised Cement Decoration .. .. .. 251
Modern Methods of Concrete Construction .. 110
New Developments in Surface-Treated Concrete and Stucco. By J. C. Pearson and J. J. Earley .. 396
New Uses for Cement in South Africa .. .. 22
North-Eastern Railway. Concrete Sleepers .. 165
Place of Concrete in the Coming Era on the North American Continent, The. By Edwin Tomlin 20, 101

PAGE
Porous Concrete 775
Position of the Reinforcement in Concrete 766
Practical Notes on Problems in Concrete Construction. When to Strike Moulds 60, 131
Presidential Address of the Concrete Institute 806
Pressure of Concrete against Forms 460
Questions and Answers relating to Concrete 67, 140, 291, 426, 501, 649, 708, 780
Recent British Patents Relating to Concrete 270, 555, 823
Retaining Walls for Large Buildings 155
Retaining Walls without Buttresses 599
Royal Agricultural Show, The Concrete Section at the 546
Sea Walls on a Treacherous Clay Foundation, Reinforced Concrete 247
Sewers and Conduits, Reinforced Concrete 113
Sewer Construction, Concrete in 402
Sleepers, Concrete, on the North-Eastern Railway 165
Surface Treated Concrete and Stucco 396
Trimstone and Building Ornaments 635
Water Tower, Design for 182

**HOUSE AND COTTAGE BUILDING:**
Amesbury 234
Blackpool 591
Bognor Hutting Scheme 533
Brighton 178, 674
Bristol. Concrete Houses at 458
Brockley 809
Bulwarks and Pennsylvania Villages, Chepstow 371
Chepstow 371
Cottage Building with the Australia Concrete Block Machine 173
Coventry 313
Dormanstown 84
Folkestone, Housing Scheme at 450
Hertfordshire 24, 595
Housing Exhibition at Olympia 193
Leeds 737
Liverpool and Coventry 313
Mass Production of Cottages, by Anglo-Australian Resident Engineer 470
Meanwood Housing Scheme, Leeds 737
Newbury Housing Scheme 469
Notes on a Suggested Solution of the Housing Problem. By a Civil Engineer 92
Poole Corporation, Parkstone 31
Potters Bar, Hertfordshire, Some Houses in 24
Proceedings of National Conference on Concrete House Construction in the United States 743
Southport 672
Specifications for Cement Concrete Buildings 539
Uxbridge 668

**HOUSING NOTES:**
Aberdare 219, 293
Abersychan 69
Acton 146
Bangor 146
Birmingham 69
Bolton 293
Bootle 68
Braintree, Concrete Houses at 146
Bristol 293
Canada and Wooden Houses 69
Cement Concrete Building Blocks 144, 219
Cheshire 293
Concrete and Housing Schemes 508
Concrete Block Houses 69
Concrete Cottages and Damp Courses 715
Contracts under the Housing Act 436
Cottage Building Experiment, A 69
Dagenham Garden City, The 846
Falmouth 219
Grants for New Methods of Construction 434
Hendon 146, 219
House of Commons 68
Hammersmith 219
Hanworth, New Garden Suburb at 653
Hertford, Cottages at 145
Housing Congress, Lyons 436
Huts for the Arctic, Concrete 145
Ideal Village, An 324, 435
International Housing Congress 507
Langbank 436
L.C.C. and Methods of Building Construction 68
Leeds 146, 220
Liverpool 324
Llanelly 324
Manchester 68, 146, 220, 293, 436
Ministry of Health 653
Montrose 220
North Sheen 146
New South Wales 69
Penybont 324
Poole 69
Poured Concrete Houses 293
Solid Concrete Walls built in situ 293
Special Methods of House Construction 653

PAGE
Standard Specification for Cottages 293
Swansea 436
Tilbury. Large Housing Scheme 435
Tiverton Housing Scheme 846
Wandsworth 220
Worthing 220
Yeovil 69

**MEMORANDA, GENERAL:**
Ambi Block for Houses, The 432
Argentine, Reinforced Concrete in the 847
Australia, Reinforced Concrete in 847
Brew House, Reinforced Concrete for 258
Bridge across the Connecticut, Reinforced Concrete 506
Bridge at Kentford, A New 405
Bridge 1,100 ft. long 769
British Engineering Standards Association (Incorporated 1918) 581
British Honduras 582
Building Blocks, New 783
Building Concrete by Unskilled Labour 846
Building in France 433
Building Services in France, New 727
Building Trade Exhibition, The 218, 292
Caissons, Concrete 217
Castings for Machinery, Concrete 218
Cement Asbestos Gutters and Down Pipes 715
Cemented Fagots for dealing with a Pit-Shaft Subsidence 580
Cement Plaster and Gypsum 580
Cement Roofing Tiles 565
Chemical Industry, Concrete in the 218
Civil Engineers, Institution of 258
Coal Cylinder Plant, A Concrete 250
Coal Handling Dock, New Concrete 365
Coast Protection at Rhyl 67
Concrete Ashlar 576
Concrete Cast in Paper Moulds 219
Concrete Institute, The 116, 356, 419
Concrete Tile 747
Concrete Utilities Bureau 426
Concrete Work in Winter 258, 750
Contracts Open 656, 785, 849
Cooling Towers at Oldham, New 774
Correspondence 502, 509, 711, 845
Cracks in Concrete 497
Curing Concrete Pavements laid in Warm Weather 639
Department Store for Leeds, New 580
Difficulties of Transport and Material 218
Disabled Men's Exhibition 405
Dublin 258
Dye Works, Perth, New 649
Educational Lectures 742
Effect of Coal on Concrete 215
Effect of Salt Water on Brickwork 215
Electrical Accidents, Concrete and 647
Employment of New Materials, The 219
Engineering Enquiry, The 713
Errata Notes 366, 719
Factory in Scotland, A Reinforced Concrete 366
Fence Posts, Concrete 607
Fire Resisting Sheathing and Insulator, A New 630
Fish Market at Grimsby, New 366
Fluid Concrete for Casting 765
Ghent 434
Good Concrete Water-tight under 35 ft. Head 501
Grab Dredging Plant in the Fen District 707
Hampton Court 258
Horticultural Structures, Concrete for 431
Indo-China, Constructional Work in 142
Inspection of Engineering Material, The 61
Institute of Physics, Air 410
Institution of Civil Engineers, The 258
Interlocking Building Blocks 846
Iron and Steel Institute 582
Large Room without Columns 846
Lawn Benches, Concrete 145
L.C.C. Regulations and Reinforced Concrete 356
L-Rails and Concrete Structures 577
Light Concrete Hangars with Curved Roofs 494
Logs of Concrete 580
Machine Surfaced Flooring 421
Maxwelltown Mill 506
Mineheads of Reinforced Concrete at Camphansen near Sarrebruck 141
Mine Shaft Houses, Concrete 434
Mine Work, Reinforced Concrete for 119
Ministry of Health 649
Modder East, Reinforced Concrete at 687
Navy Dirigible Hangar at Lakehurst, N.J. 463
New Companies Registered 72, 149, 224, 298, 439, 512, 586, 656, 720, 786
New Methods and Materials 223, 294, 436, 847
New Reinforced Galleries at Chester 846
Overhead Shafting Lines, Concrete for 269
Patent Applications Published 150, 224, 298, 366, 440, 512, 586, 656, 720, 786
Personal 147, 437, 585, 786, 850

379786

PAGE
Pipes, Concrete .. .. .. .. .. .. 71
Pipes made by the Centrifugal Process, Reinforced Concrete .. .. .. .. .. .. 69
Porete .. .. .. .. .. .. .. 630
Poyet Floor, The .. .. .. .. .. 647
Pre-Cast Concrete Pipe for Plunger Pits .. .. 781
Precautions Necessary in Concrete Work, Some .. 143
Pre-Saturated Sand Facilitates Concrete Mixing .. 843
Proportion of Water required when Gauging Concrete, The .. .. .. .. .. .. 576
Proposed New Works and Works in Progress .. 220
Publications Received 146, 149, 439, 582, 655, 850
Quay at Gateshead, Reinforced Concrete .. .. 780
Rapid Curing of Concrete Blocks .. .. .. 715
Reconstruction in France .. .. .. .. 433
Reconstruction of Churches in the Devastated Areas, The .. .. .. .. .. .. 215
Refrigerators, Concrete .. .. .. .. 783
Reinforcing Bars for Concrete .. .. .. 425
Reinforced Concrete Posts as Road Warnings .. 67
Reinforced Insulite .. .. .. .. .. 783
Research .. .. .. .. .. .. 716
Resistance of Concrete to Repeated Blows .. 143
Restoring Hawser Piles with Concrete .. .. 716
Revision of Reinforced Concrete Specifications in Canada .. .. .. .. .. .. 780
Royal Agricultural Show, Darlington .. 433, 716
Sailors' Hostel in Commercial Road .. .. 71
Salt Water on Brickwork, The Effect of .. .. 215
Salvaging Steel Reinforcement .. .. .. 362
School Building, Reinforced Concrete .. .. 433
Scientific and Industrial Research .. .. .. 581
Scientific and Technical Books .. .. .. 291
Self-sinking Concrete Piles .. .. .. .. 61
Sewage Purification Tank .. .. .. .. 702
Sewerage Work, Concrete in.. .. .. .. 717
Shanghai, New Bridge at .. .. .. .. 667
Shop Fronts .. .. .. .. .. .. 292
Signalling Concrete Mixer by Lights .. .. 135
Simple Apparatus Repairs Defective Concrete Columns .. .. .. .. .. .. 765
Sleepers, Concrete .. .. .. .. .. 71
Sleepers for Light Railways, Reinforced Concrete.. 792
Soaking Concrete in Magnesium Fluosilicate and Sodium Silicate .. .. .. .. .. 630
South America, Reinforced Concrete in .. .. 362
Stadium in U.S.A., A Large .. .. .. 580
Standard Specifications for Concrete and Reinforced Concrete .. .. .. .. .. .. 255
Strengthening Concrete Piles by Explosive Charge 838
Swimming Baths, Concrete for .. .. .. 780
Telegraph Posts at Hampton Court, Concrete .. 651
Telephone Booths, Concrete .. .. .. 269
Temporary Structures, Concrete for .. .. 142
Tenders .. .. 437, 508, 582, 655, 719, 785, 847
Testing Concrete Trucks .. .. .. .. 576
Testing Sand for Impurities .. .. .. 648
Trade Notes .. 295, 439, 509, 583, 655, 717, 785, 847
Travelling Cranes of Reinforced Concrete .. .. 140
Tunnel Construction, Concrete in .. .. .. 141
Underground Tanks, Cost of .. .. .. 360
Unnecessary Complication in the Design of Reinforced Concrete Structures .. .. .. 217
Viaduct Building in Chicago.. .. .. .. 474
Waterworks Construction, Concrete in .. .. 508
Water Supply of Victoria, B.C., The .. .. 379
Wellington, N.S.W., A Reinforced Concrete Bridge at .. .. .. .. .. .. 486
What is Portland Cement? .. .. .. .. 361
Whitby Harbour Improvement .. .. .. 144
Wine Tanks, Concrete .. .. .. .. 506

**NEW METHODS OF CONSTRUCTION:**
Autobond Building Blocks .. .. .. .. 773
Channells System, The .. .. .. .. 429
Clifton Ewart System .. .. .. .. 147
Economic Floors and Roofs .. .. .. .. 578
Hayes System of Concrete Cavity Walling .. 839
Hollow Concrete Block, A New .. .. .. 147
Hy-speed System of Construction .. .. .. 71
Jefferies Patent System of Concrete Block Construction .. .. .. .. .. .. 713
T. Elson Hardy System of Construction, The .. 504
Whitehall Concrete Co. .. .. .. .. 146

**RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE:**
Attrition of Concrete Surfaces Exposed to Sea Action. By J. S. Owens, M.D. .. .. .. 199
Cement Concrete Pavements in New Zealand and the United States and Canada .. .. .. 42
Concrete Roads .. .. .. .. .. 283
Consistency of Portland Cement, Mortar and Concrete. By H. G. Lloyd .. .. .. .. 411
Elliptical Vaulting as a Primary Factor in Contemporary Architecture, The Use of .. .. 120
Manifold Uses of Concrete, The .. .. .. 418
Mystery Port, Richborough. By Major Halstead 479
Practical Application of Reinforced Concrete, The 284
Reinforced Concrete Fence Posts .. .. .. 280

PAGE
Steelwork in the New London County Hall .. 349
Ventilation of Concrete Buildings, The .. .. 563
Warehouse Design. By Henry Adams, M.S.A. .. 127

**RESEARCH:**
Behaviour of Reinforced Concrete Columns under Fire Test. By Walter A. Hull .. .. 187, 262
Deterioration of Structures in Sea Water, Notes on the. By Prof. E. R. Matthews .. .. 392
Effect of Fineness of Cement .. .. .. 751
Effect of Hydrated Lime and other Powdered Admixtures in Concrete .. .. .. .. 688
Effect of Storage of Cement .. .. .. 545
Effect of Tannic Acid on the Strength of Concrete 689
German Fire Tests on Reinforced Concrete Houses. By Arthur Holmes, D.Sc. .. ..345, 406, 487
Permeability of Concrete .. .. .. .. 781
Stability of Thin Walls and Heat Transmission through Thin Walls .. .. .. .. 530
Test of a Concrete Floor Arch .. .. .. 836
Tests of Concrete in Tension .. .. .. 731
United States Bureau of Standards.. .. .. 348

**ROADS:**
Abergavenny and Brecon Main Road, Wales .. 818
Causes of Cracks in Concrete Pavements .. .. 256
Concrete Roads. By Edwin Tomlin .. .. 321
Construction of the Best Concrete Highway in Canada, The. By A. E. Wynn, B.Sc., etc. .. 167
Economy in Concrete Road Construction .. .. 568
Longhoughton Road, Northumberland .. .. 819
Main North Road, The, Northumberland .. .. 820
Newport to Cardiff Main Road, The .. .. 103
Northbrook Street, Newbury .. .. .. 466
Portsmouth Gasworks, Reinforced Concrete Roads at the. By S. E. Whitehead .. .. .. 386
Results of American Experience in the Use of Hydrated Lime in Concrete Roads. By A. E. Wynn .. .. .. .. .. .. 606
Roads and Public Works Exhibitions, The .. 47
Some Recent Views regarding Concrete Roads in the United States .. .. .. .. .. 820
Story of Concrete Road told in Pictures .. .. 259
Toronto-Hamilton Highway, The .. .. .. 167

**ROAD NOTES:**
Aberdeen .. .. .. .. .. .. .. 220
Australia, Concrete Roads in .. .. .. 653
Brighton .. .. .. .. .. .. 107
Concrete Roads .. .. .. .. .. 639, 841
Denmark, Concrete Roads in .. .. .. 715
Experimental Roads in Somerset .. .. .. 395
Forms for Concrete Roads .. .. .. .. 779
Gum Tragasol Co., Road for the .. .. .. 221
Lampeter, Proposed Reinforced Concrete Road for 221
Marylebone .. .. .. .. .. .. 436
Newbury .. .. .. .. .. .. .. 436
Pre-Cast Concrete Road Slabs .. .. .. 607
Rapid Road Construction .. .. .. .. 46
Road Foundations in the City, Concrete .. .. 782
Road Making .. .. .. .. .. 107, 220
Some Recent Views regarding Concrete Roads in U.S.A. .. .. .. .. .. .. .. 820
Steel Ribs on Wide Concrete Finishing Belt to prevent Warping .. .. .. .. .. 46
Watney Combe Reid Co. .. .. .. .. 509
Yorkshire .. .. .. .. .. .. 107

**RULES AND REGULATIONS:**
Rules Governing the Design of Reinforced Concrete Flat Slabs in New York City .. .. 703

**SHIPBUILDING:**
Chinese Built Concrete Motor Ship, A 2,200-ton .. 287
Concrete Shipbuilding. By A. B. Searle 136, 209, 285, 343, 420, 492
House Boat, A Concrete .. .. .. .. 287
Largest European Concrete Vessel, The .. .. 696
Motor Ships built in Denmark, Concrete .. .. 287
Patching a Ship with Concrete .. .. .. 61
Preston, A New Barge Launched at .. .. 137
Motor Coaster in the Argentine, A Concrete .. 137

**THEORETICAL:**
Calculations for Continuous Beams with Third-point Loading. By Ewart S. Andrews, B.Sc. Eng. .. .. .. .. .. .. .. .. 732
Calculation of Rigid Frames. By V. Elmont, B.Sc. 380
Concrete in Theory and Practice 207, 288, 357, 422, 498, 566, 701, 770, 831
Economical Design of Reinforced Concrete Foundation Slabs. By Chas. S. Higgins .. .. 617
Formulæ for the Economical Design of Rectangular Beams, particularly as regards Shear Resistance, New .. .. .. .. .. .. .. 243
Maximum Stresses in Short Circular Columns of Masonry, Eccentrically Loaded. By R. E. Stradling .. .. .. .. .. .. .. .. 793
Problems in the Theory of Construction .. 80, 161, 732
Reinforced Concrete Simply Explained. By Oscar Faber 207, 288, 357, 422, 498, 566, 701, 770, 831
Rigid Reinforced Concrete Frames. By Ewart S. Andrews .. .. .. .. .. .. 80, 161

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7

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## CONTENTS.

**Editorials.**

**The Dalmarnock Power Station, Glasgow.**

**The Place of Concrete in the Coming Era:**
On the North American Continent.
New Uses for Cement in South Africa.

**Concrete Cottage Building.**

**Reinforced Concrete Bunkers and Water Tower.**

**Recent Views on Concrete and Reinforced Concrete:**
Cement and Concrete Pavements in New Zealand and the United States.
By WALTER E. BUSH, M.Inst.C.E., &c.

**The Roads and Public Works Exhibition.**

**Practical Notes on Problems in Construction.**

**Metaforms.**

**Questions and Answers Relating to Concrete.**

**Memoranda.**

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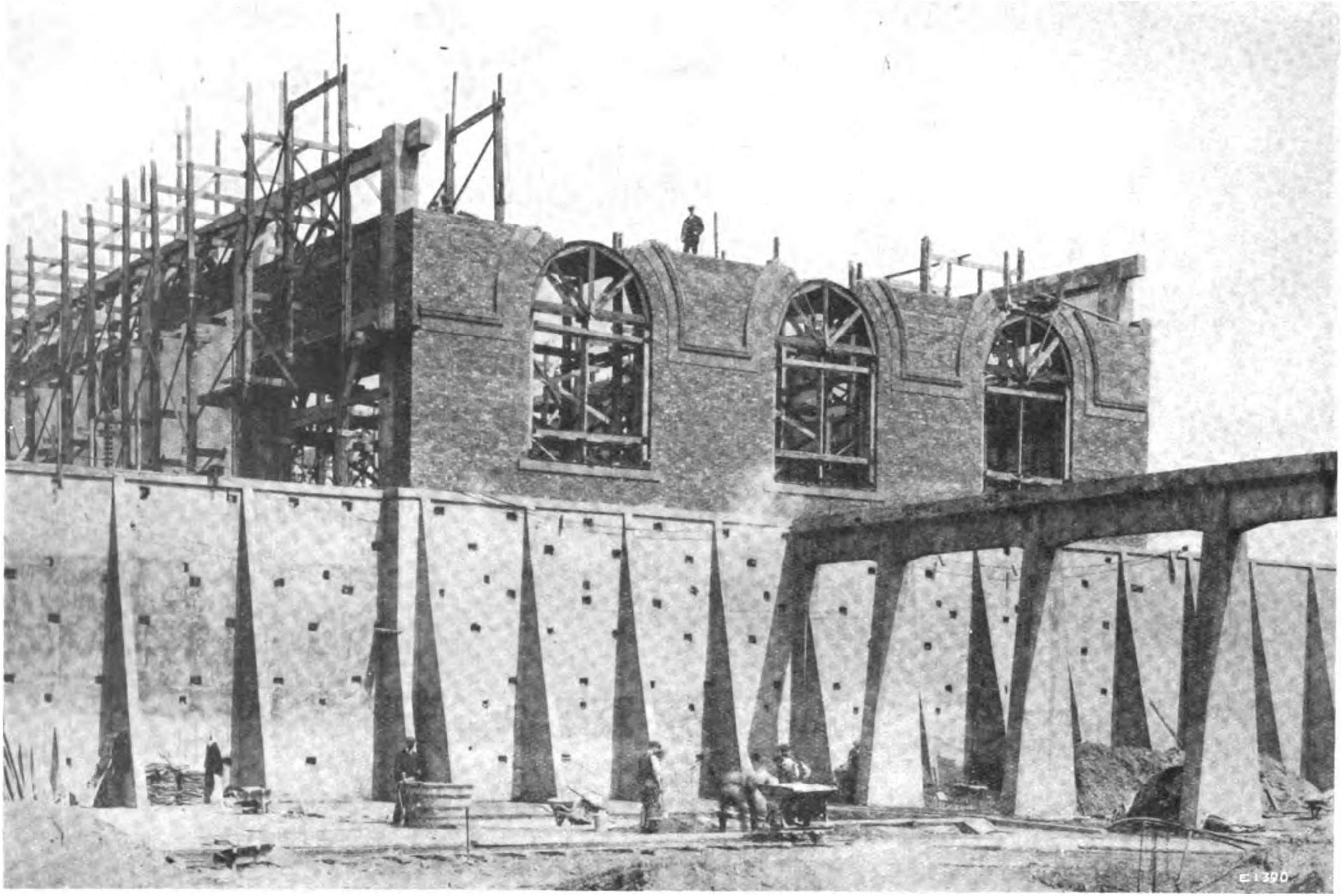

**Dalmarnock Power Station, Glasgow.**

*(See page 7.)*

# CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XV. No. 1. LONDON, JANUARY, 1920.

# *EDITORIAL NOTES.*

## THE ROAD TRANSPORT CONGRESS AND CONCRETE ROADS.

AT the inaugural luncheon on November 20th last, before the opening of the Exhibition and Congress at the Agricultural Hall, Sir Eric Geddes, the Minister of Transport, said, *inter alia*, that the cost of the roads had gone up enormously, and that " the remarkable thing was that not only had the cost of building the roads gone up, but additional expenditure did not mean a decreased upkeep ; the more expensive the construction, the more expensive was the annual upkeep."

This may be perfectly true with regard to certain descriptions of road construction, but does Sir Eric Geddes know that in America, where a sufficiently long trial of concrete roads now exists, it has been found that the cost of such roads properly constructed and with a fairly concentrated traffic does not exceed £40 a mile ?

When we read that the Wayne County Commissioners started laying concrete roads in 1908, and that it is now contemplated constructing no less than 40 million square yards of concrete roads in the United States during the forthcoming year, is it likely that such a level-headed race would continue to make roads of this description if it was a fact that " the more expensive the construction the more expensive was the annual upkeep " ?

At the opening of the Congress, on the day following this luncheon, Mr. W. Mathews Jones, M.Inst.C.E., the City Engineer of Chester, presented a paper on concrete roads, in which he stated, *inter alia*, that an unsurfaced concrete road which he had constructed seven years ago, with a daily traffic of about 120 tons, and which had cost only 5s. 1d. per sq. yd. to build, had given " complete satisfaction," and had only cost an average of 1½d. per sq. yd. per annum to maintain, and that in view of this successful trial his corporation had instructed him to lay a reinforced concrete road right through the main thoroughfare of Chester, with an estimated traffic of 1,500 tons a day, and that if this work proved successful he intended to recommend the construction of eight miles of road in a similar manner. This work, he stated, was already well in hand.

Mr. Walter E. Bush, M.Inst.C.E., the City Engineer of Auckland, New Zealand, followed with a paper (of which an abstract appears in this issue) on the same subject, and said he had commenced laying concrete roads in 1915, and that up to March 1919, 35,000 sq. yds. of streets of this character had been finished, 14,000 sq. yds. were in hand, and 135,000 sq. yds. had been authorised. He also gave an interesting account of the Canadian and American roads which he had inspected, and he finished by stating that this form of road had come to stay as an important factor in providing facilities for traffic. In the discussion which ensued the usual arguments were brought forward against the use of unsurfaced concrete, viz.: (*a*) The necessity for diversion of the traffic for at least three weeks in order to let the concrete set; (*b*) that concrete possessed no resiliency or elasticity; (*c*) that it was liable to crack; (*d*) that the surface abraded under the traffic of steel or iron-tyred vehicles.

### NECESSITY FOR EXTENDED TRIAL.

The majority of the speakers, however, seemed to be in favour of an extended trial of concrete roads in this country. Mr. J. A. Brodie, M.Inst.C.E., the eminent City Engineer of Liverpool, said that he had no fear as to the wear of concrete roads under general traffic, " and it was a remarkable thing that America had at the present time from 8,000 to 10,000 miles of concrete roads, whilst we were talking of experiments." We thoroughly agree with Mr. Brodie's remarks. and it is a matter for wonder why there is such an evident reluctance on the part of road engineers in this country to give a fair trial of concrete roads on a large scale. What are the reasons for this attitude towards concrete roads? It may arise from uncertainty as to the results, for although there is extensive evidence of the success of such roads in America and elsewhere, the small trials that have been made in this country, although convincing to some engineers, have not yet been widely studied or appreciated. It may be that some engineers seem to prefer to follow the safe side of precedent and convention, rather than risk what, to them, is a novelty. This attitude unfortunately appears also to be shared by the expert advisers of the Ministry of Health, who are still clinging to the archaic traditions of the now defunct Local Government Board which pertained when reinforced concrete was first brought under their notice, many years ago. The Board then persisted, for a very long time, in doubting the stability of such construction, and would only grant permission to borrow loans for the purpose at ridiculously short terms for repayment. It is sincerely to be hoped that the rumours that the Ministry of Health will only give five-year periods for concrete roads are without foundation, as otherwise such a decision would seriously block all progress in this direction.

### TIME REQUIRED FOR SETTING.

The question of the time required for the concrete to set is really of no importance as, in most cases, the traffic can be temporarily diverted until the green concrete has become sufficiently hard. Then there is the " bogey " of subsequent cracks, which may be dismissed if the concrete has been properly mixed and laid, and even if any cracks do eventually appear, have we not ample evidence, from America and elsewhere, that they are easily and economically dealt with?

### THE SURFACE OF CONCRETE ROADS.

As to the " harsh " character of the surface of a concrete road, and its possible attrition by iron or steel-tyred wheels, this is easily remedied by a thin coating of tar and chippings, or some other bituminous or asphaltic mixture, laid on the surface.

### COST.

With regard to cost: in view of the greatly increased price of the various " bituminous " compounds hitherto so largely used, and the present cost of labour, concrete roads should compare favourably in their first cost with other forms of construction, and it has been proved that, when once laid, concrete roads require very little repair, and that their subsequent cost of maintenance bears very favourable comparison with other road materials.

Portland cement concrete is known to grow stronger and stronger with time, and, therefore, with the exception of the possible attrition of the surface due to the traffic, there is no inter-attrition or movement of the particles of the concrete, and consequently no deterioration of the structure, which is by no means the case with many of the other forms of construction. It may further be claimed for a concrete road that the surface never becomes wavy or corrugated, and also that the camber may be of less gradient than some other roads.

### CONCLUSION.

Concrete gives an ideal surface for the rubber-tyred wheels of self-propelled traffic, and was chosen for the celebrated Brooklands motor racing track. It is practically non-slippery under the most trying climatic conditions. This is an important factor in view of what was repeatedly urged at the Congress, viz. :—that horses were yet using our roads in large numbers, and that they must be considered for some time to come with a view to providing them with non-slippery road surfaces. Looking dispassionately at the possibilities of concrete as an alternative method of road construction in this country, it is evident that it must, at no distant date, take its place amongst other methods which have been adopted. At present it has to cope with prejudice, partiality, and prudence, but it is to be hoped that the newly constituted Ministry of Transport will take a wider view of the subject, and that an exhaustive trial will be made of this type of road in order to prove or disprove its merits.

Such a trial should be conducted on a scale that would necessitate the employment of modern concrete mixing machinery, as well as mechanical means for putting the concrete *in situ*. It should be carried out under strict supervision and under a very careful and comprehensive specification. At the above-mentioned Congress a resolution was unanimously carried, calling on the Government to institute scientific investigation on this question, and it is to be hoped that this important matter will not be allowed to drop.

It was refreshing to observe at the Congress that the question of concrete roads was no longer received with the coldness which has characterised former discussions on the subject, but that there appeared to be almost a general feeling amongst those who were present that " after all there does appear to be something in concrete roads."

We trust this feeling may extend, and that before long the question of concrete roads will take its place amongst our highway engineers in the same manner as it has now been dealt with for so many years past by the engineers of the United States of America and elsewhere.

## THE CONCRETE INSTITUTE.

THE Presidential Address to the Concrete Institute, delivered on November 28th, printed in our December issue, was probably of interest to our readers, as showing the present and prospective activities of this centre. Mr. Searles-Wood was somewhat discursive, and dealt with such varied fields as conditions of contract, details of specific reinforced concrete design, and forthcoming examinations. Referring to the Whitley Industrial Councils, the President thought that the representation of the Institute upon them would be advantageous, and laid stress on the necessity of abstract ideas formulated by such councils taking material shape. We all feel at present that the tremendous volume of mental effort expended by the vast number of government and other industrial committees should begin to produce a tangible effect in improving the actualities of life, and though patience is very properly enjoined, on entering the second year after the armistice, the public may reasonably look forward to some results at no very distant date. There seems, indeed, some danger that the well-intentioned governmental efforts to improve national industrial conditions may result in considerable stifling of individual effort by bureaucracy unless care is exercised. Mr. Searles-Wood is optimistic about a gradual settling down in the building and engineering trades, but points out that as output is still 20 per cent. below pre-war figures, greater production is essential.

### CONDITIONS OF CONTRACT.

Turning to conditions of contract, we are given a useful summary of various forms in use at the present time. The Institute of Builders is now considering the R.I.B.A. amended form, while the National Federation of Building Trade Employees is expected shortly to produce a national building code. As regards the usual lump sum contract, it is contended that it is too rigid, the builder taking all risks. No doubt as things stand at present this is true, but it must not be forgotten that in normal times, when prices tend to vary in the direction of a fall as well as a rise, the builder may have advantages under such a contract. We are so resigned to things going up that we are apt to lose sight of this aspect, but it must be remembered that any new form of contract generally accepted is intended to operate for many years to come. As regards the Scottish form largely used by the Government during the war, under which the whole of the work is measured on completion and priced at pre-decided rates, this, as stated in the address, throws all risk on the employer. For emergency national work this arrangement may be suitable, but we cannot get away from the fact that the private employer must usually have some—at least approximate—notion of his outlay before he commits himself, and that these indefinite undertakings involve great labour, and hence considerable expense in the matter of professional oversight. After all, the trade wishes to encourage the public to build, and though it can dictate its own terms now, it should take a long view to make these reasonable with a view to the future.

The prime cost plus profit system, we are glad to see, is looked upon as requiring considerable safeguards. We can hardly imagine that such a system, which was admittedly a war emergency arrangement, can ever become general. It has the inherent defect of indefinite liability for the building owner, and it offers no incentive whatever to rapid progress on the part of the contractor. Of course, it may be said now that there is so much work that it is to the interest of a contractor to complete without delay, but in times of less pressure such a system would have many temptations, and it would be only human for a firm to use such contracts as useful stand-bys when urgent matters which would not admit of delay came along. Besides this, the definition of prime cost is very difficult, as has been pointed out by Mr. Ruisnett and other writers; an exceedingly crisp undertaking as to what is meant by this term is necessary, and the amount of supervision and inspection of books which must be undertaken by the architect and his surveyor is very great if the building owners' interests are to be adequately safeguarded. This must mean more fees, and these usually fall on the employer. Even now we have not dealt with what we regard as the most objectionable aspect of this arrangement, which is that the builder actually receives a profit on the cost of any delays and additional expenses which the system entails.

### REINFORCED CONCRETE CONSTRUCTION.

Turning to details of reinforced concrete construction, Mr. Searles-Wood gave particulars of an interesting dome erected at the Port of London Authority's new building by Mr. Edwin Cooper. We do not propose here to go into the figures and calculations given, but the work appears to be an admirable example of economical construction, wherein the stresses have been so calculated as to give the requisite stability with the minimum of material. For work of this character reinforced concrete is of course admirably adapted, and, further, lends itself readily to suitable internal treatment without the necessity for the intermediate assistance of timber bracketings required by bare steel.

### THE ACTIVITIES OF THE INSTITUTE.

Certainly the most important part of the addresss was devoted to the present and proposed activities of the Institute. We almost wish, indeed, that the President had taken these matters as a very ample text and confined himself to them. During the past year we are told that a carefully drawn list of the properties of concrete aggregates has been prepared with a view to obtaining information from municipal surveyors, and that this information will be co-ordinated and published when received. This is a most important matter at the present time, and with the present cost of transport great economy will be effected by the use of local aggregates in all building and engineering work, and it is urgently necessary that ready advice upon all kinds of local materials should be forthcoming. The use of destructor clinker, for example, is a case in point. This necessarily contains some sulphur. How much can be allowed, and, given this information. how can rapid tests be made to check the amount ? These are the kind of things we want the Institute to tell us at once. We hear further that a sub-committee is considering the British Standards Specification for cement with a view to suggesting amendments. Much has been learnt from the chemist and physicist in recent years, and we think it quite likely that improvements in this specification are possible. High-tension steel has also come under consideration, and in this connection we may refer to the President's reminder that the Institute's activities are not confined to purely concrete matters, but embrace more general questions of engineering. The Science Committee of the Institute is investigating cement micro-sections with a view to further elucidation of the exact nature of cement when set. Reference was made to the crystalloid theory of setting, but none to the celloid theory held by certain German authorities.

We should like this celloid theory confirmed or exploded—here is another useful field of work which we commend to this Institution.

After referring to the loss of several eminent members, the President finally turned to the subject of the examination which it is now proposed to hold for the first time early next summer. This development is of the greatest importance and merits separate consideration, which we propose to defer to a later issue.

## NOTES.

COMMENCING with the present issue we are introducing a new feature in our journal and, at the request of many of our readers, we propose this year to devote a short section each month containing notes of especial interest to contractors, supervisors, clerks of works and others who are in charge of the actual execution of work. Practical notes and hints will be given, illustrated occasionally by sketches and photographs, and, where possible based on actual experience. The various aspects of concrete work will be dealt with. In the current number the question of shuttering is dealt with.

## CONCRETE COTTAGE CONSTRUCTION.

THIS current year will probably witness an extensive development in cottage building, and there is no doubt whatever that concrete will be widely used for many of the proposed schemes. We, therefore, would again call attention to the volume recently published, entitled *Concrete Cottages, Small Garages and Farm Buildings*, which can be obtained from our publishing offices, and of which a limited number of copies are still available. (Price 5/6 post free.)

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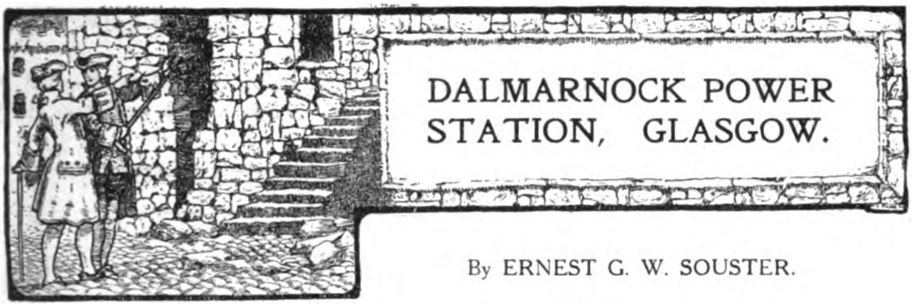

# DALMARNOCK POWER STATION, GLASGOW.

By ERNEST G. W. SOUSTER.

*The new electricity station for the Glasgow Corporation is a particularly interesting example of a recent structure in which reinforced concrete has been extensively used.—ED.*

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THE general trend of modern civilisation is for all sources of supply and production to be controlled by large corporations, and whilst this tendency was developing previous to 1914, the years of war have so altered conditions that it is probable that bulk supply and mass production are absolutely necessary if demands are to be quickly and economically fulfilled.

This tendency has been realised by the Corporation of the City of Glasgow, who are erecting at Dalmarnock a super-station for the generation of electricity; and so progressive has been their electricity department that many firms who have hitherto produced their own power are now scrapping their plants and obtaining more economical power and light from the Corporation.

Reinforced concrete has played an important part in the construction of this power station, and the whole of our illustrations are reproduced from the detailed drawings of the Considère Construction Co., of Victoria Street, who were responsible for the designing of the reinforced concrete work, in accordance with the instructions of the chief electrical engineer to the Corporation, Mr. W. W. Lackie.

## GENERALLY.

The site of the buildings is near Dalmarnock Bridge, and covers an area of approximately eleven acres. Its proximity to the Clyde allows for continuous and abundant supply of water, whilst the Lanarkshire coalfields assure abundant coal supply at relatively low costs for freightage.

The station is being erected in sections, but the whole of the coal store, which has a capacity of 75,000 tons, is now approaching completion. A feature of this store is the transporter, which runs from end to end of the store, and which has a span of 190 ft. This and the coal conveying plant is so arranged that the coal can be deposited or lifted from any part of the store and conveyed to the overhead bunkers in the boiler-house. This plant will be capable of receiving 1,000 tons daily, and is arranged so that the coal may be either conveyed direct to bunkers over boiler-house or placed in the store.

The boiler-houses are designed in accordance with most modern practice, and are shown in *Figs.* 1–12. As will be seen from *Fig.* 3, which shows Boiler-house No. 1, the ground floor contains space for the ash conveying machinery and forced draught fans.

The boilers are placed on first floor, and consist of 8 boilers by Babcock & Wilcox, with a steaming capacity of 62,000 lb. per hour at 275 lb. per sq. in.

steam pressure; and above the boilers are the hoppers for immediate coal supply, and over the boilers is the economiser and chimney space.

Adjoining the boiler-house, but separated from it by a reinforced concrete framed wall with brick panel filling is the turbine room, which will contain 5 turbo-alternators, each capable of developing continuously 18,750 k.w. (about 25,000 h.p.).

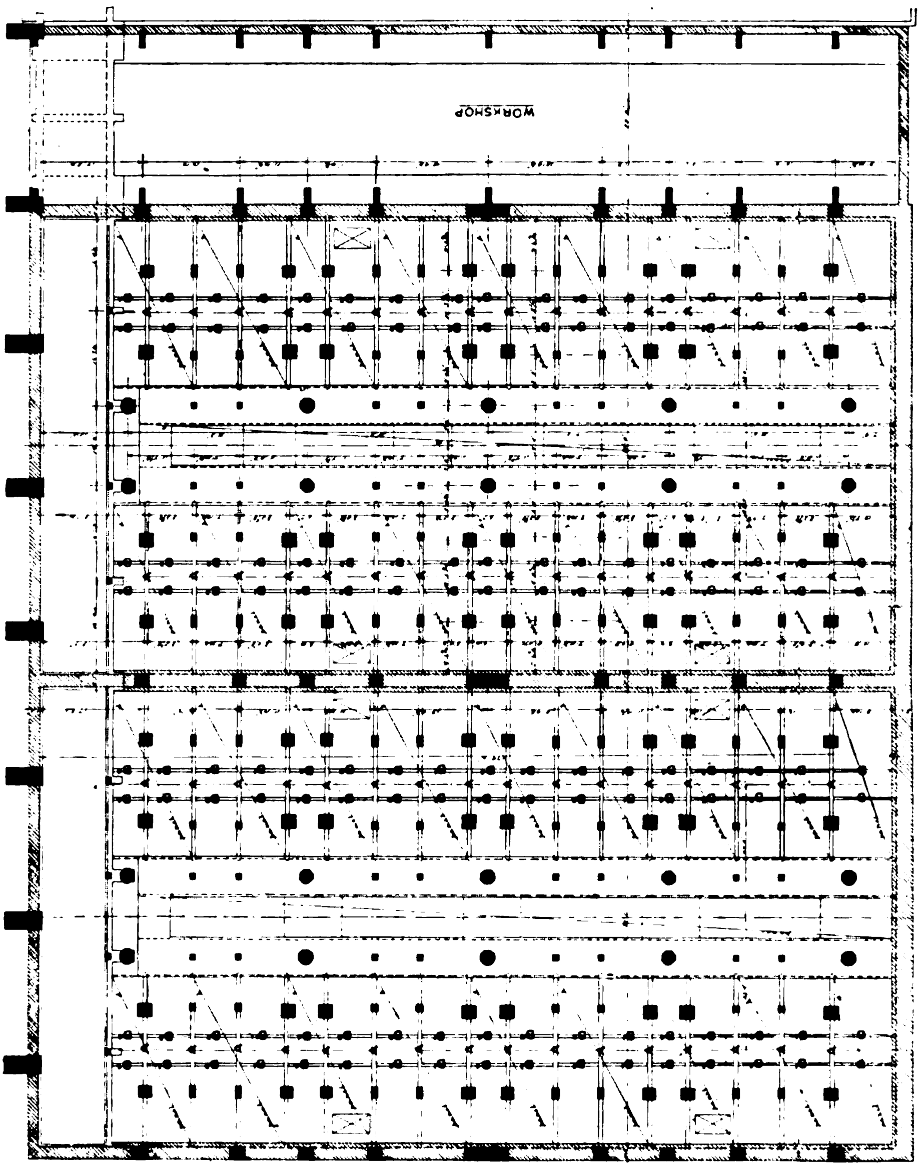


Fig. 1. Plan of Basement Floor (looking up). Boiler Houses 1 and 2.
Dalmarnock Power Station, Glasgow.

The switch-house on the ground floor will contain transforming plant for stepping-up the energy from 6,600 to 20,000 volts ; and the upper floor will contain the 20,000 volt switchgear, with a central control room.

To obtain water a concrete duct is being formed from the River Clyde, and in connection with this an elaborate screening plant is being installed to prevent floating leaves and other débris from entering the condenser tubes. It may be of interest to state that when the station is working at high pressure the amount of water that will circulate through the condensers will be approximately 10,000,000 gallons per hour.

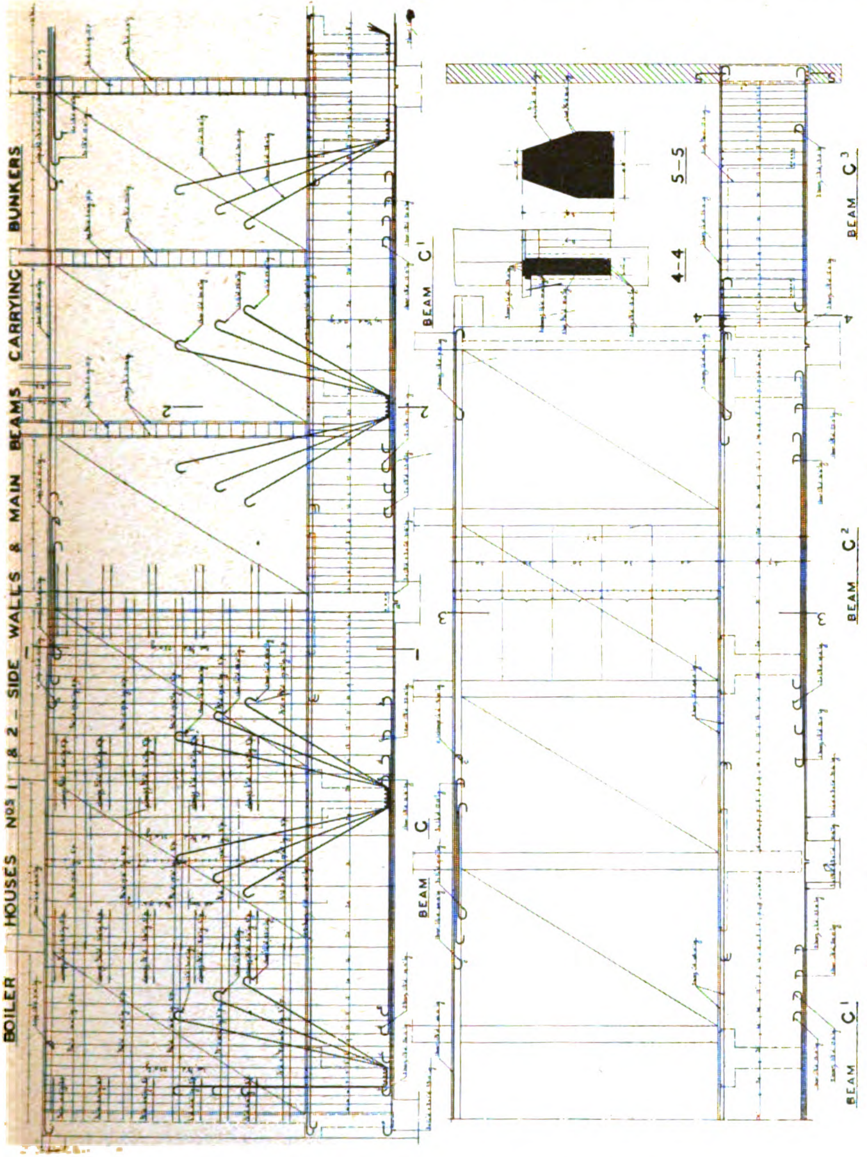
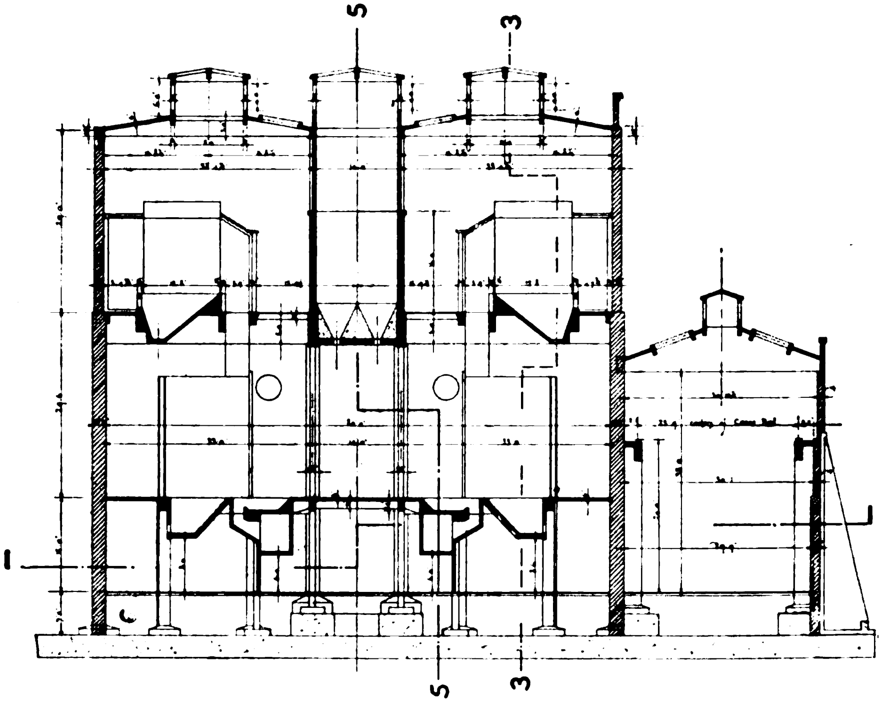

BOILER HOUSES Nos 1 & 2 – SIDE WALLS & MAIN BEAMS CARRYING BUNKERS
BEAM C¹
BEAM C
BEAM C²
BEAM C³
BEAM C¹
5–5
4–4

Fig. 2. Boiler Houses 1 and 2, Side Walls, Main Beams, Carrying Bunkers.
DALMARNOCK POWER STATION, GLASGOW.



Boiler Houses—Sections.

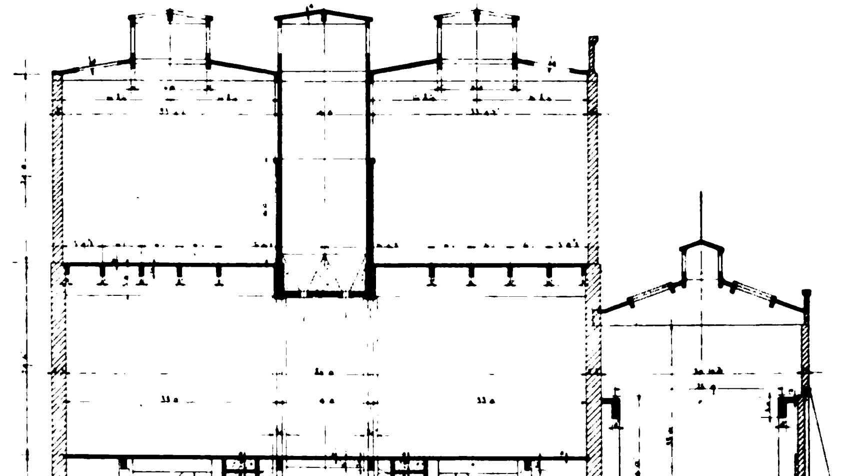
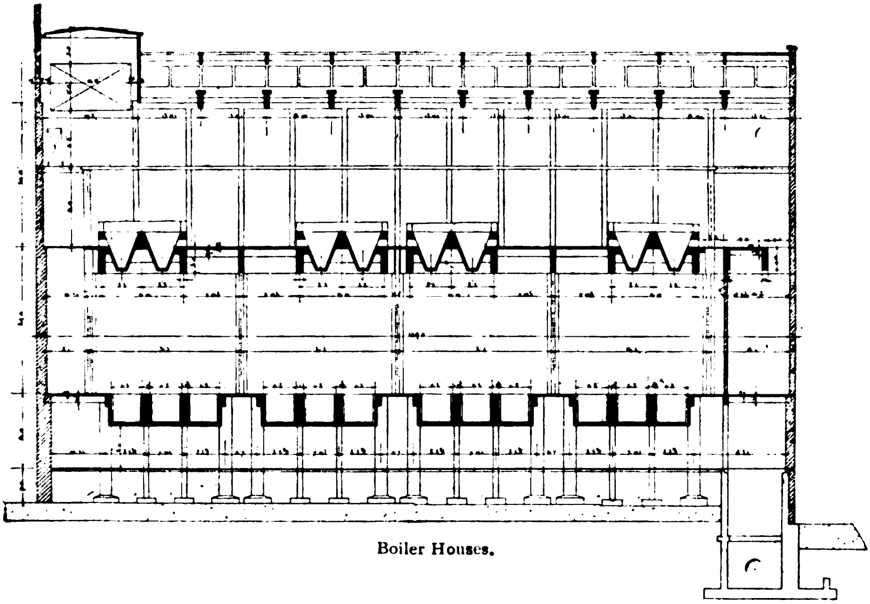


Fig. 3. Boiler Houses—Sections.
Dalmarnock Power Station, Glasgow.

The final capacity of the station will be 200,000 kilowatts, and it is estimated that the cost will be £15 per kilowatt of plant capacity, whilst coal consumption will not exceed 2 lb. of coal per unit generated.



Boiler Houses.

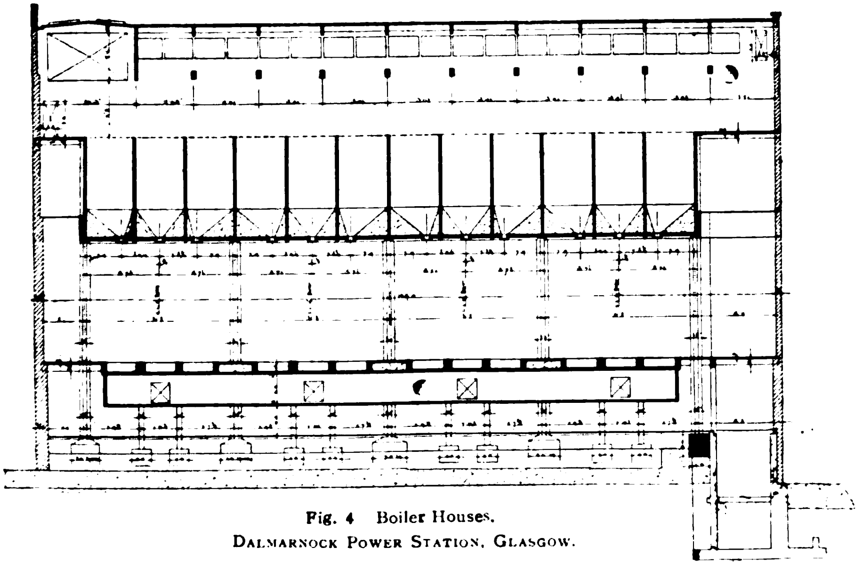


Fig. 4 Boiler Houses.
Dalmarnock Power Station, Glasgow.

CONSTRUCTION.

The whole of the works and the station and its adjuncts are noteworthy examples of the use of reinforced concrete, not only on account of its size, but also because the designs include almost every type of structure which can be usefully and economically constructed of this material.

As an example of this the coal store is surrounded by a large retaining wall, the design of which was prepared after close investigation as to the best type of section to adopt, with a view of combining a high theoretical efficiency with the maximum economy of material.

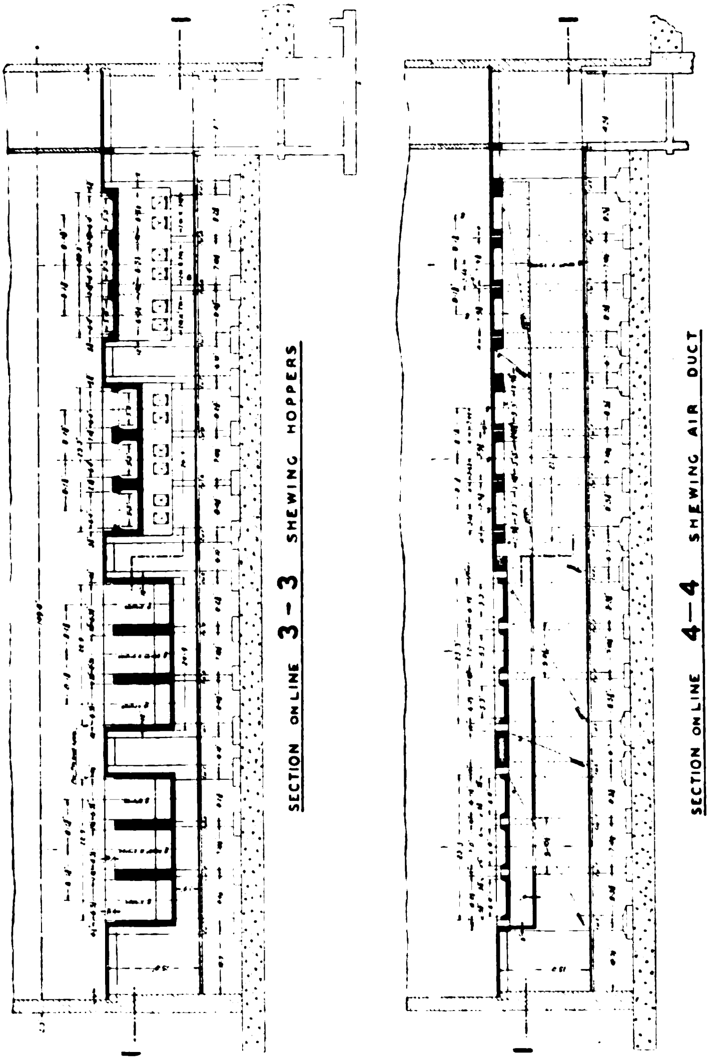

SECTION ON LINE 3-3 SHEWING HOPPERS
SECTION ON LINE 4-4 SHEWING AIR DUCT

Fig. 5. Firing Floor, Part General Plan. Boiler Houses.
Dalmarnock Power Station, Glasgow.

For the girder carrying one end of the transporter, and for the girder carrying the traveller in the engine-room house, rectangular beams of reinforced concrete, supported on stancheons of the same material have been adopted. These girders had to be calculated for the rolling loads produced by the transporter and the traveller respectively.

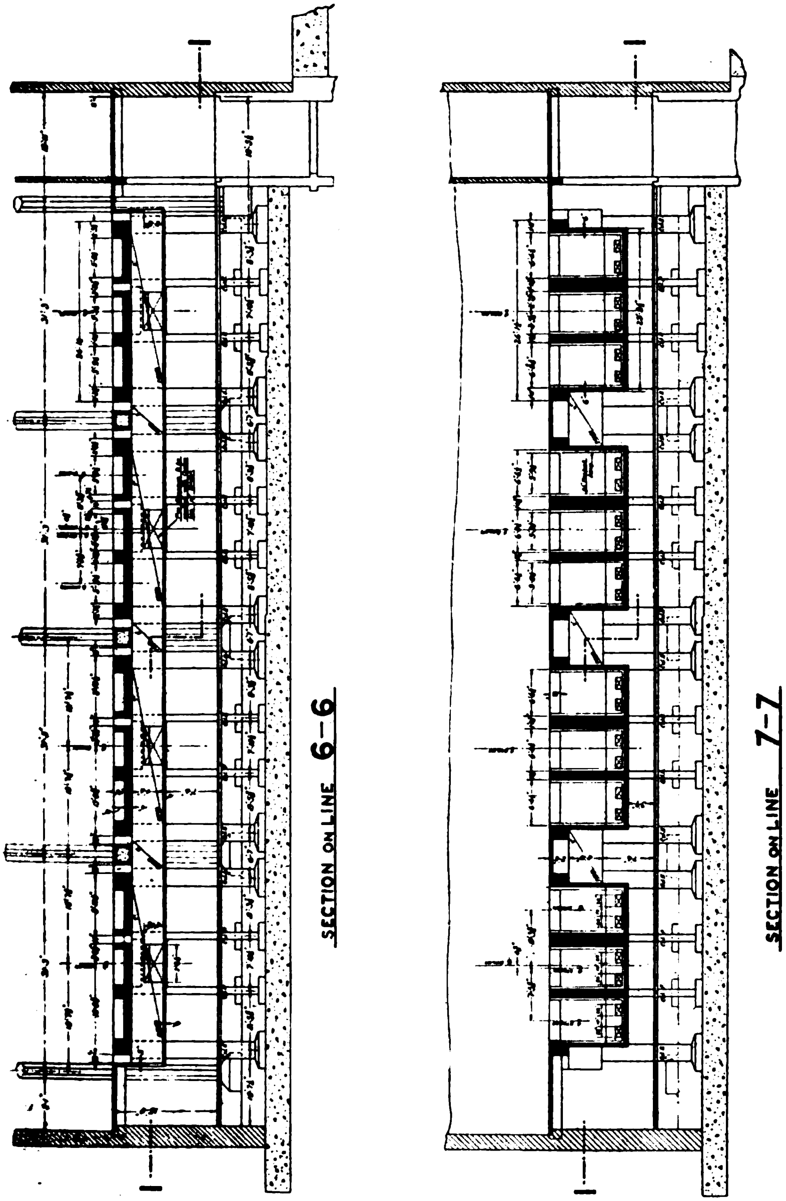
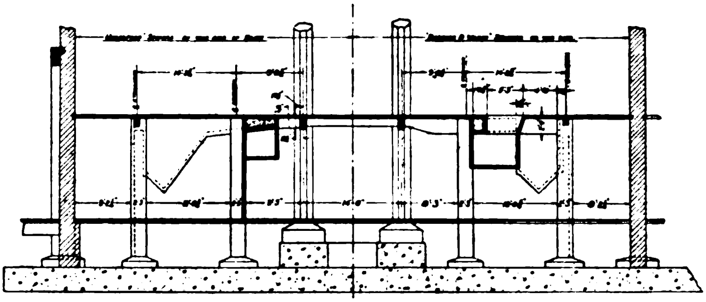


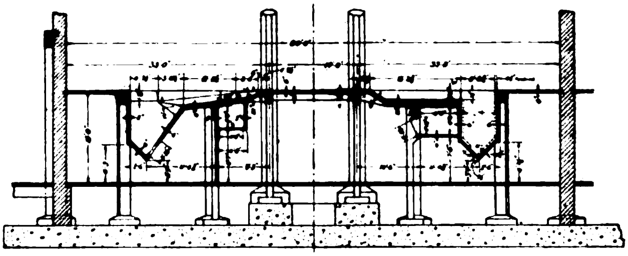
Fig. 6. Firing Floors. Part General Plan. Boiler Houses.
Dalmarnock Power Station, Glasgow.

The boiler-house is a unique building in reinforced concrete construction, and it will be seen from the accompanying details that the side walls of the bunkers have been made to perform the double function of resisting the thrust of the coal, and at the same time acting as longitudinal girders spanning between the columns, thus allowing the columns to be spaced at wide intervals in spite of the excessively heavy loads required to be carried on the economiser floor. These columns, which carry enormous loads, were kept within a reasonable size by the adoption of an octagonal section, reinforced with vertical bars and the well-known Considère system of spiral reinforcement.

The conduits, or ducts, for the intake and outlet of the condenser water are also of reinforced concrete, and the sides and bottom had to be designed so as to take either the thrust of the earth from the outside or the pressure of the water from within.



SECTION ON LINE 5—5



SECTION ON LINE 2—2

Fig. 7. Firing Floor. Part General Plan. Boiler Houses.
DALMARNOCK POWER STATION, GLASGOW.

It will be seen from the photographs and drawings which accompany this article that the design of the reinforced concrete work entailed not only an immense amount of labour, but also engineering ability of a high standard; and some idea of the amount of work involved in the preparation of the reinforced details may be gathered from the fact that the drawings and steel lists prepared for the contractors give the lengths and diameters of over 400,000 bars, and the reinforcement required for the works amounts to over 1,400 tons.

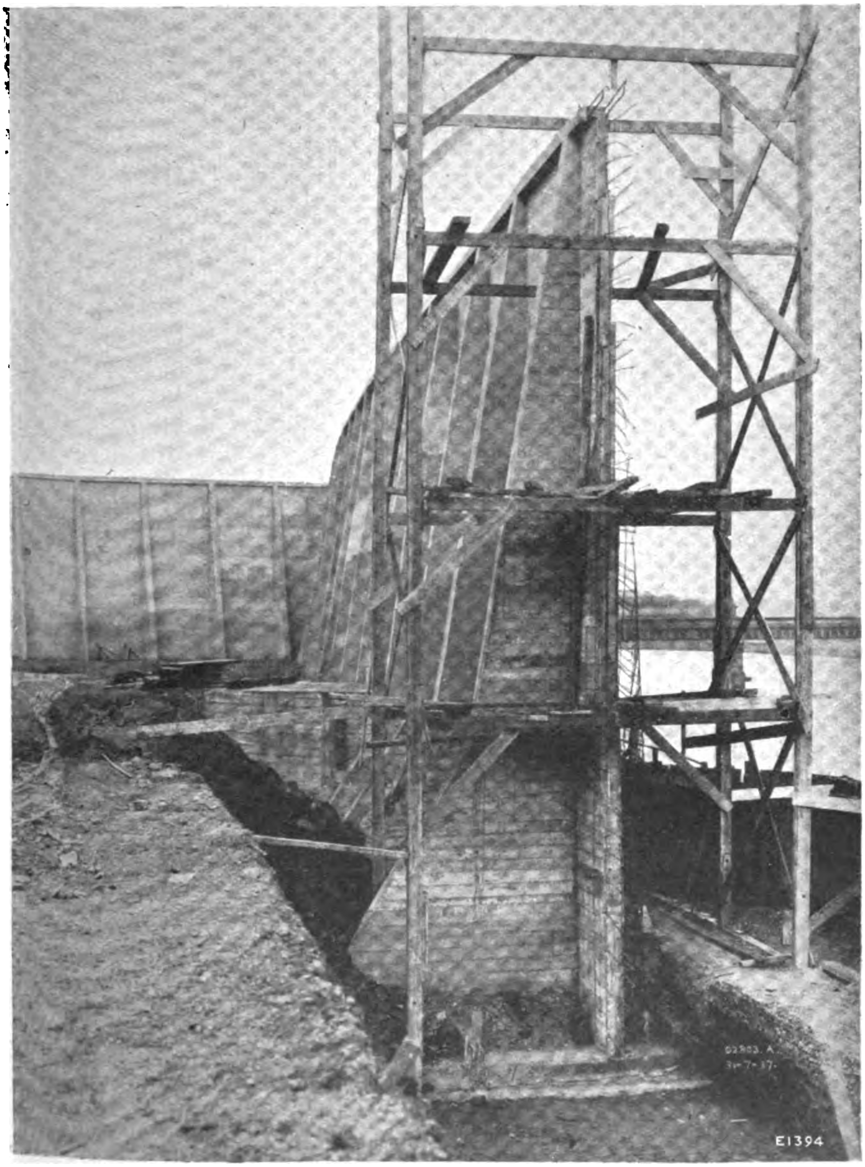
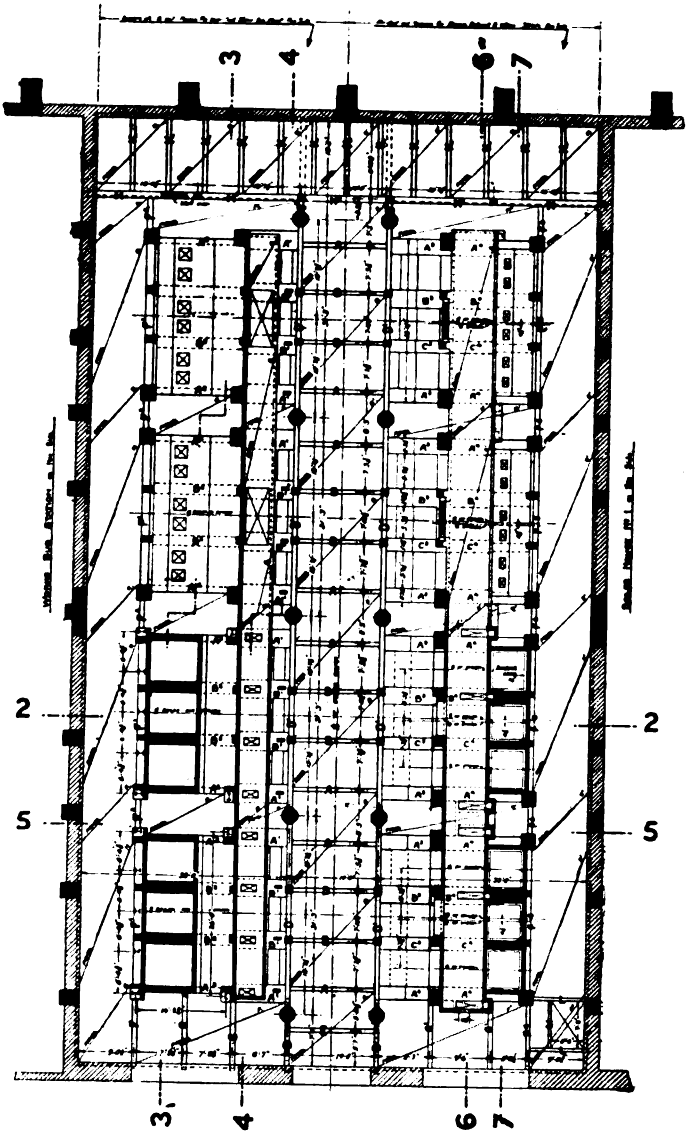


Fig. 8. Retaining Wall around Coal Store.
Dalmarnock Power Station, Glasgow.



SECTION ON LINE 1—1 (LOOKING UP) SHEWING FIRING FLOOR

Fig. 9. Boiler House.
DALMARNOCK POWER STATION, GLASGOW.

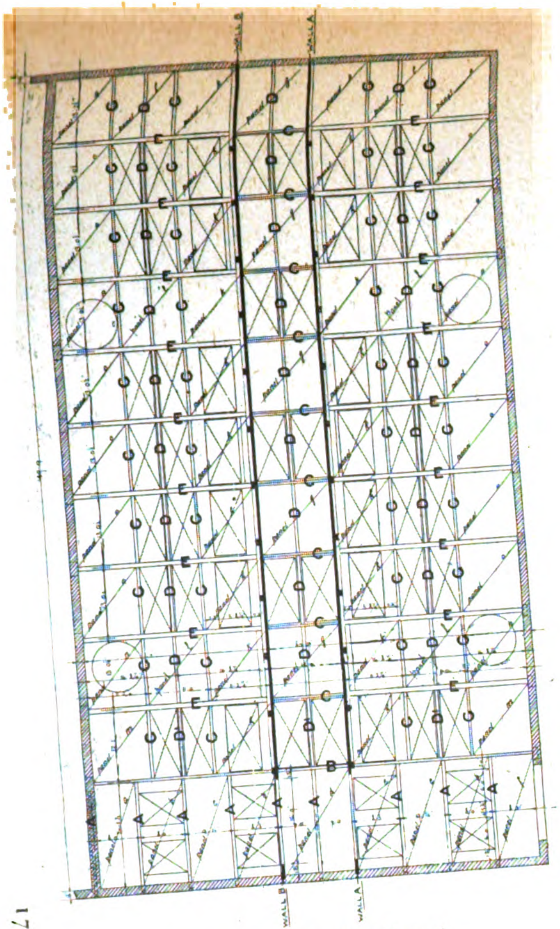
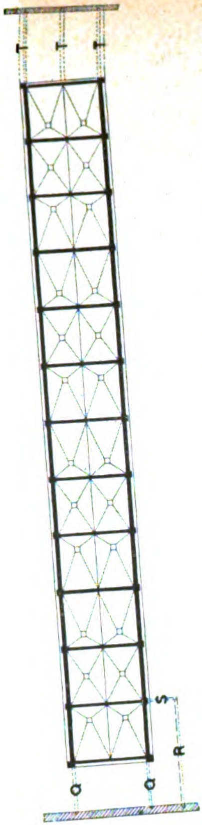
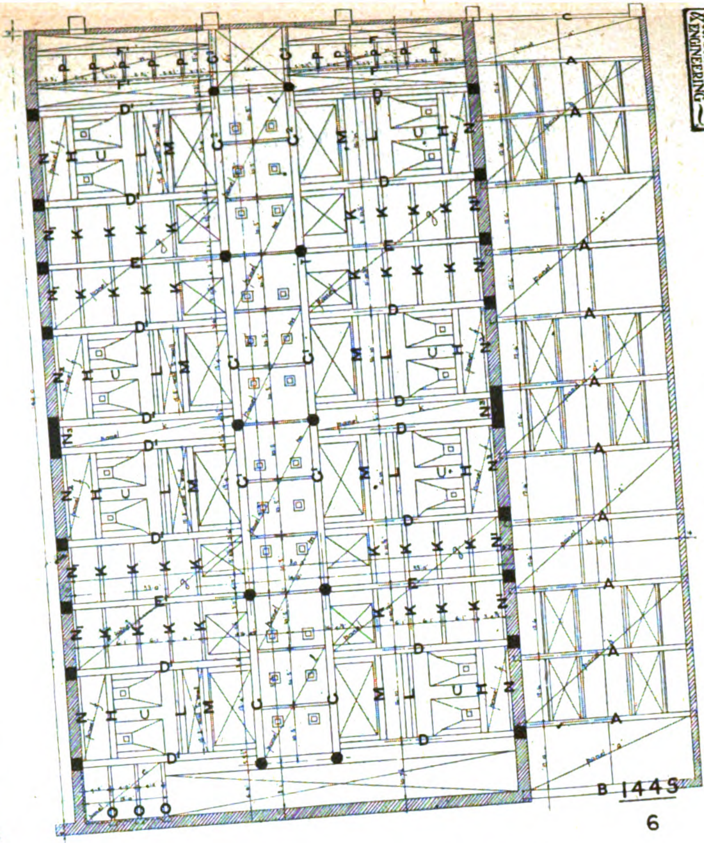


Fig. 10. Plan of Roof (looking up).



Sectional Plan through Bunker.

Boiler Houses Nos. 1 & 2.
DALMARNOCK POWER STATION, GLASGOW.



Plan of Economiser Floor (looking up).

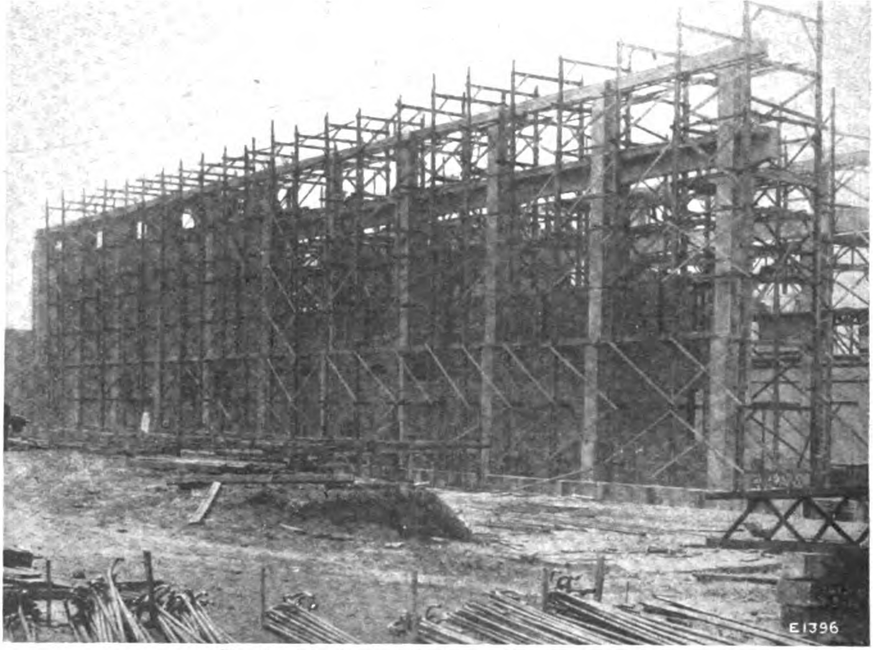


Fig. 11. Exterior of Boiler House, showing Shuttering.

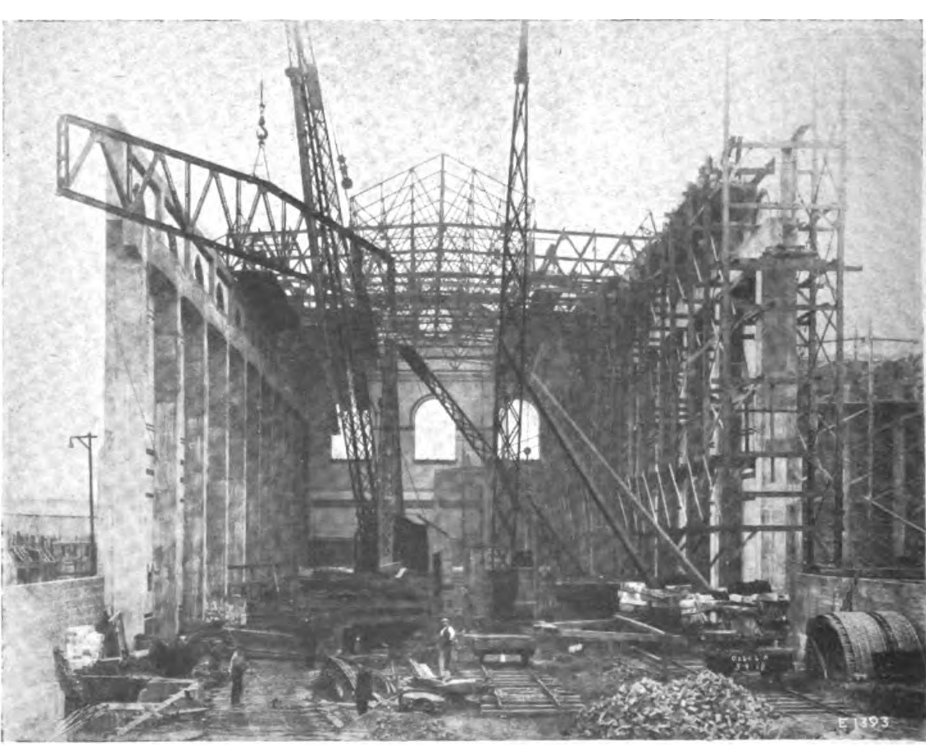


Fig. 12. Turbine House during Construction.
DALMARNOCK POWER STATION, GLASGOW.

In addition to this station, the Glasgow Corporation Electricity Department has decided to make use of reinforced concrete for several of the sub-stations required in connection with their scheme of development.

The contractors for the works at Dalmarnock are Messrs. Train & Taylor, of 153, St. Vincent Street, Glasgow.

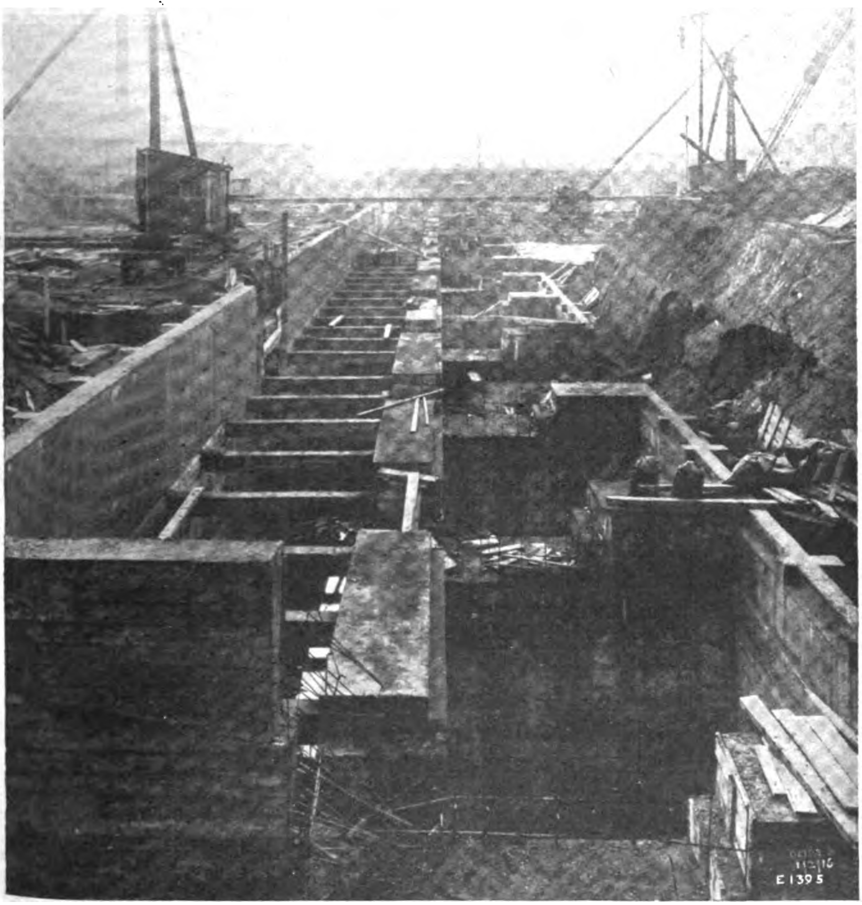
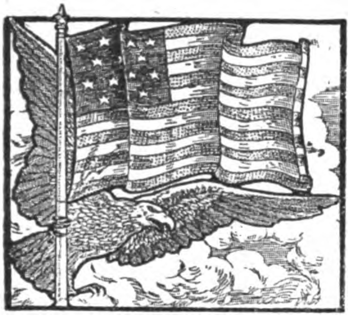


Fig. 13. Condenser, Water Duct and Pump Chambers.
Dalmarnock Power Station, Glasgow.



# THE PLACE OF CONCRETE IN THE COMING ERA, ON THE NORTH AMERICAN CONTINENT.

By **EDWIN TOMLIN**, Victoria, B.C.

PERHAPS in no other way has the development of Canada and the United States been more strongly illustrated than in the consumption of Portland cement during the last twenty years. The trend of general opinion on the American continent becomes with each passing year more strongly inclined to permanent construction in public and private works of all kinds, and, as a result, we should see a most striking increase in the use of concrete construction during the next twenty years.

A survey of the particular uses to which reinforced concrete is being put at the present time proves very interesting. In many ways it has absolutely displaced earlier methods and inferior materials without any danger whatever of the latter ever becoming popular again.

### GRAIN ELEVATORS.

In Canada and the United States with their immense cereal producing areas, it was absolutely necessary to find some form of storage for the harvest which would be fire, vermin, moisture, rot and waste proof. After many years of experience with wood, brick and steel, we find the standard type of grain elevator all over the American continent is now reinforced concrete. These huge structures can be found from the Atlantic to the Pacific, and from Northern Alberta to the Mexican border. Canada is fully abreast of her American neighbour in the latest improvements for housing grain and other cereals, and some of the latest types of reinforced concrete grain elevators may be seen at Vancouver, British Columbia, and Fort William, Ontario. As the grain-producing areas of Canada and the United States increase, as they will do very materially during the next twenty years, we may expect to see many scores of new concrete elevators erected all over the continent. These elevators are practically indestructible and will constitute one of the greatest advertisements, generation by generation, to the permanence of concrete.

### BRIDGES.

Another form of reinforced concrete construction which bids fair in a few years to be absolutely predominant is the reinforced concrete bridge. In Canada and the United States with their thousands of rivers, ravines and steep gorges, there is ample necessity for many tens of thousands of bridges, viaducts and culverts. In the eastern part of the continent and the middle west with their huge industrial areas producing iron and steel, for many years past the prevailing bridge has been of steel construction. In the far western part of Canada and the United States, with their immense areas of standing timber, it has been the practice to build fully 75 per cent. or 80 per cent. of the bridges and culverts required of wood. During the last few years, however, since the pendulum of public opinion has swung very strongly in favour of permanent structures, the merits of the reinforced concrete bridge have been very widely recognised, and adopted as a standard in latest practice. On all steel bridge construction there is a maintenance which must always be kept up to prevent deterioration of the framework. Similarly, in timber bridge construction replacement is absolutely necessary after a short term of years. The reinforced concrete bridge, in striking contrast, calls for no maintenance at all. From an architectural standpoint, in comparison with the other two forms we have mentioned, it can be made superior in appearance and can be built to suit any conditions. Concrete bridges, some examples of which may be seen in that majestic structure spanning the Delaware River at Portland, Pennsylvania; the Hell Gate Bridge at East River, New York; the Bow River Bridge at Calgary, Alberta; the Connecticut River Bridge at Hartford, Connecticut and the Union Railroad Bridge at East Pittsburg, Pennsylvania—all stand as instances of the permanence of concrete.

### AQUEDUCTS.

Reinforced concrete has been extensively used of late years for the construction for great aqueducts. The most recent example of this anywhere in the world is the aqueduct which supplies the City of New York. It is 111 miles long with a diameter up to 17 ft., and in places it lies 1100 ft. below the surface. It is subject to a pressure as high as 90,000 pounds per sq. ft., and delivers up to 500,000,000 gals. of water per day. This water tube is expected to supply the needs of New York City for generations to come. Over 1,100,000 barrels of cement were used in its construction.

Another recent example is the aqueduct made about two years ago at Winnipeg. Ten miles of concrete pipe 5½ ft. in diameter in 8-ft. sections were laid with absolute success, and the guarantee for tightness at the joints was exceeded when the final test was made. The wall thickness of the pipe was 8 in., and was reinforced with two concentric steel cages placed 2 in. from the inner and outer surfaces respectively. The inner reinforcing cage was built of a specially heavy woven section of triangular mesh, and the outer cage of ½ in. to ⅝ in. square twisted bars, the spacing and size varying with the 45 ft. to 90 ft. head. The tightness of the joints was effected by endless copper bands 5 in. wide, placed in the spigot of the pipe, having a closed bead rolled into it 1½ in. from one edge. This copper water stop is so placed that the bead is just at the end of the spigot, leaving 1½ in. of copper protruding. The outside end of the spigot was painted with a thin asphaltic coat to prevent the grout joint or key from bonding to the pipe itself, although the copper was roughened to ensure this key being firmly gripped by the grout which was also bonded to the bell end of the next pipe by means of the protruding mesh. This aqueduct at Winnipeg is now completely finished and in successful operation.

Another highly satisfactory aqueduct is that supplying the City of Victoria, British Columbia, with water from Sooke Lake. In this case the pipe line was 27½ miles long and the size of the concrete pipe was 42 in. This aqueduct has been in use for over six years. Other installations which could be mentioned comprise the aqueduct supplying the City of Seattle which is 42 in., the water service at Fort Worth, Texas, size 48 in., and the pressure pipe line at Baltimore, which is 108 in. in diameter. It is interesting to note that in the case of the latter installation, each section of 108-in. pressure pipe 6 ft. long weighed 11 tons.

### ROADS.

In another sphere of public utility and service, concrete bids fair to outstride all other materials in a very few years—namely, for road work. The following statistics of concrete road construction in Canada and the United States cannot fail to appeal to readers who are interested in good roads :—

| | Sq. yds. | | Sq. yds. |
|---|---|---|---|
| Prior to 1909 .. | 799,390 | Laid in 1914 .. | 14,815,034 |
| Laid in 1909 .. | 561,271 | ,, 1915 .. | 16,936,137 |
| ,, 1910 .. | 1,313,499 | ,, 1916 .. | 24,218,055 |
| ,, 1911 .. | 2,069,445 | ,, 1917 .. | 25,000,000 |
| ,, 1912 .. | 5,295,447 | ,, 1918 .. | 17,000,000 |
| ,, 1913 .. | 9,596,286 | | |
| | | | 117,604,564 |

Construction was somewhat retarded during 1918 owing to war conditions, but the volume of road work this year has provided adequate compensation, as it is estimated that more than 50,000,000 yds. of concrete roads have been laid in Canada and the United States since the beginning of 1919. Concrete roads have been subjected to the most critical examination possible by all the leading engineers and university authorities on the American continent. As experience has demonstrated during the last ten years that the old macadam road was unable to withstand the wear and tear of modern traffic, it was necessary to find some type of permanent road which could be adopted as a standard. As mentioned elsewhere in this paper, public opinion is becoming increasingly intolerant of makeshifts and it is more than ever a case of the survival of the fittest. The concrete road in competition with asphalt, bitulithic, brick, tar macadam and other types, is undeniably demonstrating its superior qualities, and I venture to state that during the next decade it will be the standard type of permanent construction on the whole of the American continent. One could tell a very interesting story of the gradual evolution of the concrete road and the improvements made both in the methods of construction and the quality of the materials. Such a narrative, however, is not the object of the present article.

(*To be concluded.*)

*In the concluding part of his article the author deals with concrete construction for harbour work, hydro-electric works, large buildings, its uses on the farm and estate, etc.*

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## NEW USES FOR CEMENT IN SOUTH AFRICA.

THOUGH Portland cement has been steadily growing in favour for constructional purposes in South Africa, it cannot be said that its use has reached the level which obtains in older countries. No doubt this is, in part, accounted for by the higher cost of cement in the Union, as compared with European countries and with the

United States and Canada (at least in normal times), but it must also be attributed in part to lack of experience concerning many of the ways in which cement has been adopted as a constructional material in the older lands. If we except the railways and other Government departments, who now employ cement in very substantial quantities, it must be admitted that the Union is much behind the countries just referred to in the realisation of its value. According to our information, its use in combination with steel for the construction of a great variety of buildings in reinforced concrete has not yet received the attention which this system deserves, although a few examples of such structures have been erected in different parts of the Union—*e.g.*, the pier at Cape Town, and a flour mill on the Rand. With the development of cement production within the Union, a gradual lowering of the price may be expected, providing the South African railways do not neutralise makers' reduced prices by further increases in transport rates. The increase already made is a very serious one and amounts to a complete reversal of the policy, adopted a few years ago, of reducing the carriage rates on cement of colonial production to figures approaching those fixed for coal. Whilst it is understood that the increase in railway rates is merely a war measure, it cannot be too clearly borne in mind that it must inevitably raise the cost of cement and proportionately discourage its consumption. Nevertheless it must also be remembered by all who are interested in building that in a first-class Portland cement they have at their disposal one of the most valuable of all building materials, because it often enables the user to employ in the most efficient manner a variety of useful and suitable aggregates found on or near the site of the building itself. If ordinary care be used and the instructions given in text books be closely followed, it is perfectly possible for unskilled, but intelligent, labour to construct a great variety of useful productions in concrete.

The concrete block is hardly used at all in South Africa at present, though its value as a substitute for brick and stone is very real. Although the manufacture of artificial slates from a combination of cement and asbestos fibre has now reached very large dimensions in England and other countries, the industry is only in its infancy in South Africa, and in this field alone there is an immense scope for development. The high price of galvanised iron sheets, which have hitherto been employed almost exclusively for roofing purposes within the Union, is bound to react sharply in favour of any sound and durable substitute, and it cannot be too strongly urged that the various forms of asbestic-cement roofing constitute one of the very finest substitutes possible for this purpose. Not only are such roofs cooler in hot and warmer in cold weather than those of galvanised iron, but the material is not liable to rust away as iron does, and if properly erected, a roof of asbestic-cement tiling should be imperishable. It can be made either in the form of small squares or diamonds, or in sheets, and the latter may be either flat or corrugated, and can be bent into shapes similar to galvanised iron. For such a material there should be an immense demand if the attention of users be directed to it. Now that cement of high quality is produced within the Union in substantial quantities there need be no lack of suitable supplies for the local production of this kind of roofing, and as asbestos of the desired quality is also found extensively in South Africa, it is unnecessary to look to distant lands for any of the materials required in its manufacture.

# CONCRETE COTTAGE BUILDING.

## SOME HOUSES IN HERTFORDSHIRE.

THE prejudice against the concrete cottage, if not obsolete, is at least obsolescent. The pressing need for increased housing accommodation has compelled the conservative mind to reconsider its attitude and to examine the claims put forward on behalf of concrete construction. The claims are manifold, and many of them are fully justified ; that the Ministry of Health is realising this may be assumed from the fact that the Construction and Standardisation Committee has already given official sanction to many forms of concrete construction, both pre-cast and site-moulded, both with and without reinforcement.

Of the many claims that are made for the extensive use of concrete, one of the most frequently heard is the fact, that the manufacture of concrete blocks is a matter of great simplicity, and one that can lightly be undertaken by unskilled labour. Herein lies a grave danger. The mechanical process of block making is undoubtedly, when compared to the manufacture of bricks, a simple matter, but the point which is liable to be disregarded is that the strength and the protective properties of the concrete are dependent upon the proper mixing of the correct ingredients in exactly the right proportions and under the appropriate conditions. Local authorities, who, in many cases, are in possession of large supplies of clinker, which, when moderately free from sulphur forms excellent aggregate, are apt to imagine that all that is necessary is to purchase a block-making machine, and to turn an untrained man to work on the manufacture of blocks in readiness for their housing schemes. The result of such a procedure will be most disastrous, and such as may be calculated to bring discredit upon concrete cottage building generally. In order that no mistake of this kind be made, it is advisable to carry out tests on the spot with the aggregate which it is proposed to use, in order to ensure that the proportions of the ingredients shall be exactly suited to the material. The greatest accuracy must be obtained with regard to the amount of water used, an excess or deficiency in the amount causing a disproportionate weakening of the blocks. Before commencing upon the erection of the first 16 houses on an estate in Hertfordshire, the drawings of which are here shown, sample blocks were made from the local aggregate by Messrs. Concrete Buildings, Ltd., with whose system they are built. These blocks were allowed to season previous to being subjected to thorough tests. By this means the danger of a damp building due to a weak mixture is obviated.

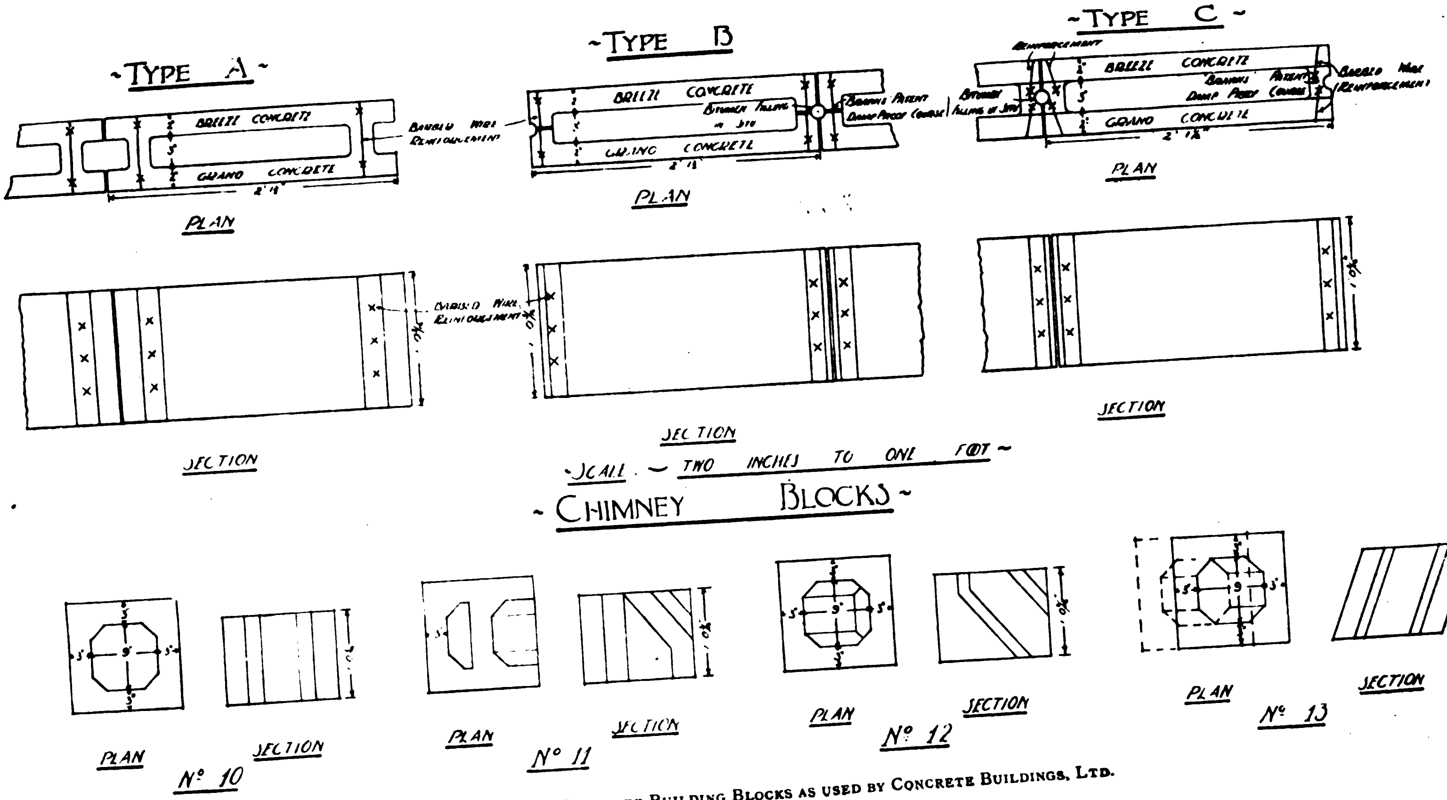


Fig. 1. Patent Concrete Building Blocks as used by Concrete Buildings, Ltd.

There is no doubt that one of the main obstacles to the extensive use of concrete as a cottage-building material is the fear of the condensation of moisture on the inside walls. This danger is generally overcome by the use of the hollow wall, the inner portion of which is made of a more porous mixture. On the other hand as a single block is undoubtedly stronger, and a building so constructed is far less liable to damage due to any subsequent subsidence, Messrs. Concrete Buildings Ltd. have, by means of extensive experimenting, evolved a block which they claim is rigid, waterproof and free from condensation. It is

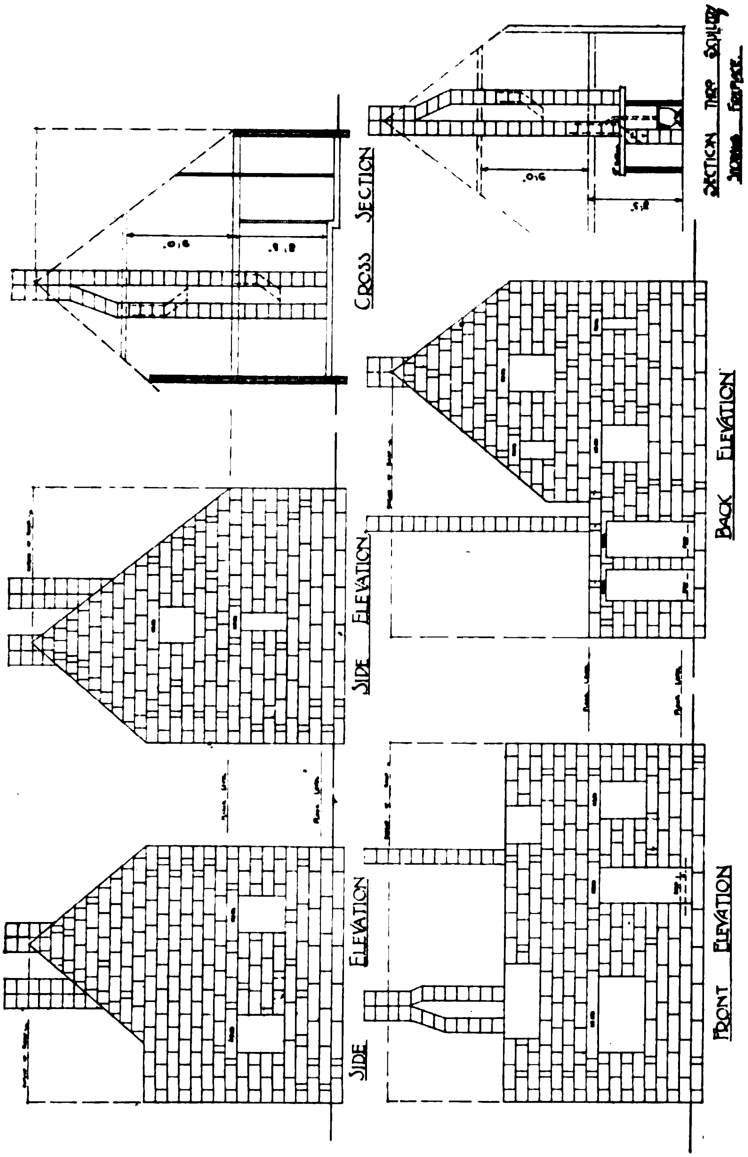
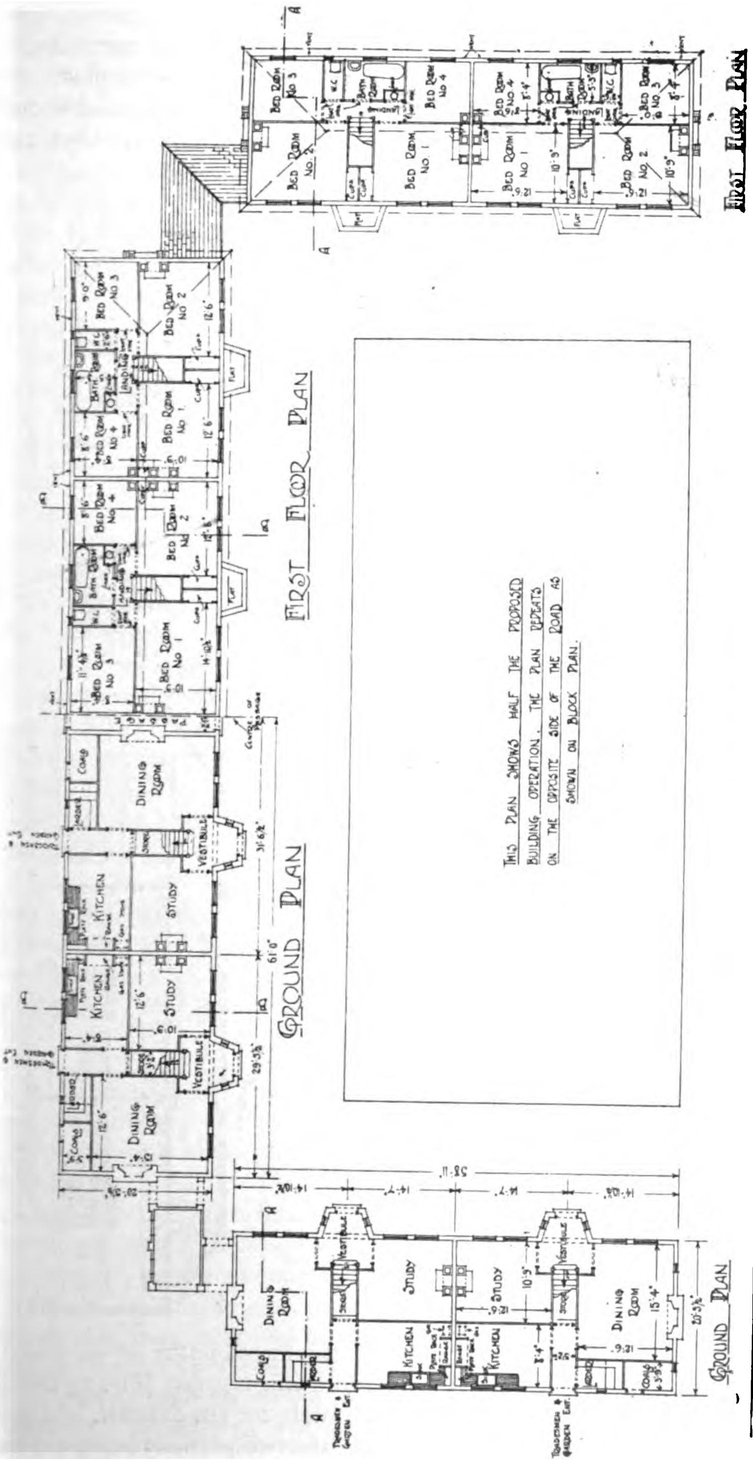


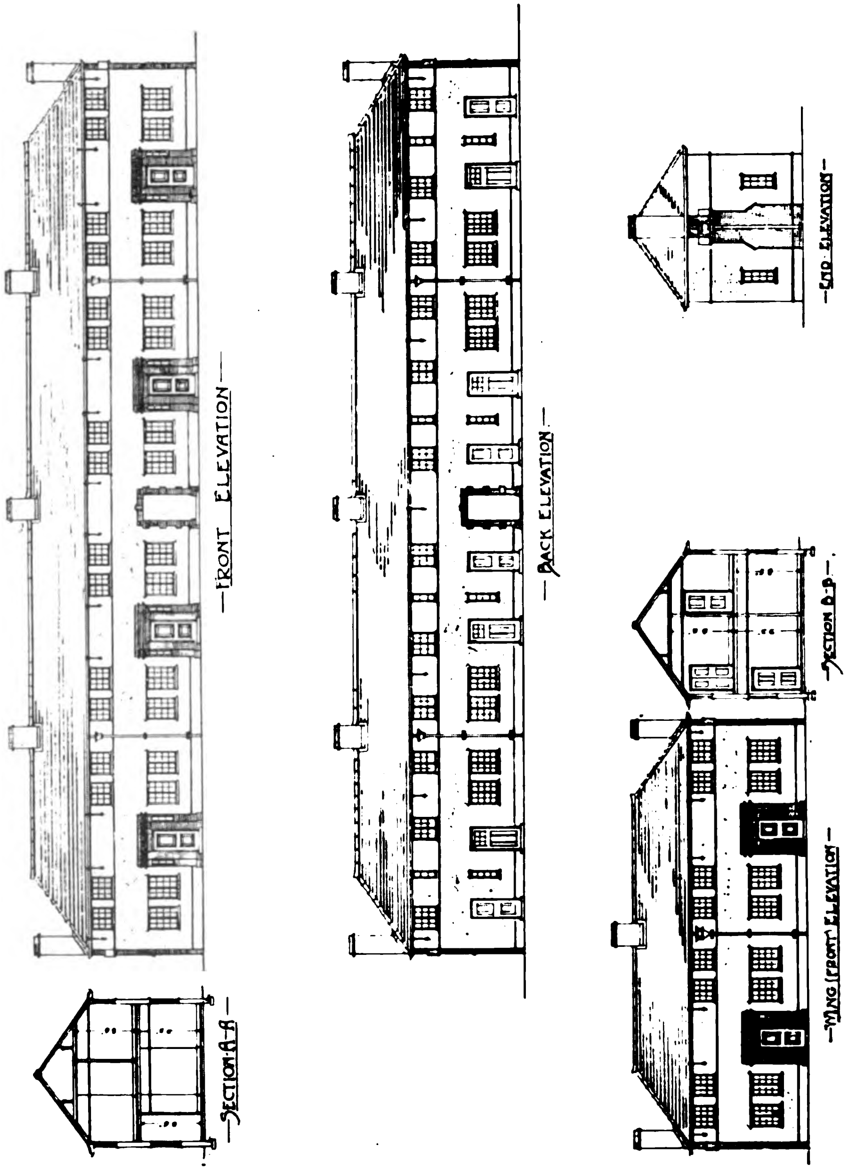
FIG. 2. PROPOSED TYPE OF HOUSES FOR THE BOARD OF AGRICULTURE AND FISHERIES. SHOWING ARRANGEMENT OF BLOCKS.



H E A T H   D R I V E

**PROPOSED HOUSES IN HERTFORDSHIRE. PLANS.**

made of ordinary concrete on the outside and breeze concrete on the inside. An immediate difficulty had to be overcome in the manufacture of a block of this description due to the fact that the shrinkage of the two types of concrete during the process of seasoning varies. This, therefore, constituted a source of danger which, however, was ultimately overcome by the introduction of vertical reinforcement. Blocks type A, B and C, of which a drawing is given, (*Fig.* 1.) are made of ordinary 6 to 1 concrete, broken to a ⅜ in. mesh, for the exterior, and breeze concrete broken to a ½ in. mesh for the interior, the two portions being armoured



Proposed Houses in Hertfordshire. Elevations.

across as shown with barbed wire. These blocks are made in the following sizes: 3 ft. 2½ in. by 1 ft. 0$\frac{3}{16}$ in., 2 ft. 1½ in. by 1 ft. 0$\frac{3}{16}$ in., 1 ft. 0¾ in. by 1 ft. 0$\frac{3}{16}$ in., and closers of half the last size. Angle blocks are also made for all angles showing 2 ft. 1½ in. on one face and 1 ft. 0¾ in. on the return face. For particularly exposed positions a specially designed block has been introduced. Block type B has a "Bravin" patent damp-proof course placed vertically throughout each web, the circular space is filled in with bitumen as the building proceeds. A slate horizontal damp-proof course is laid below each web. Block type C shows the same idea somewhat differently arranged. Both these blocks are stated to be absolutely weather-proof.

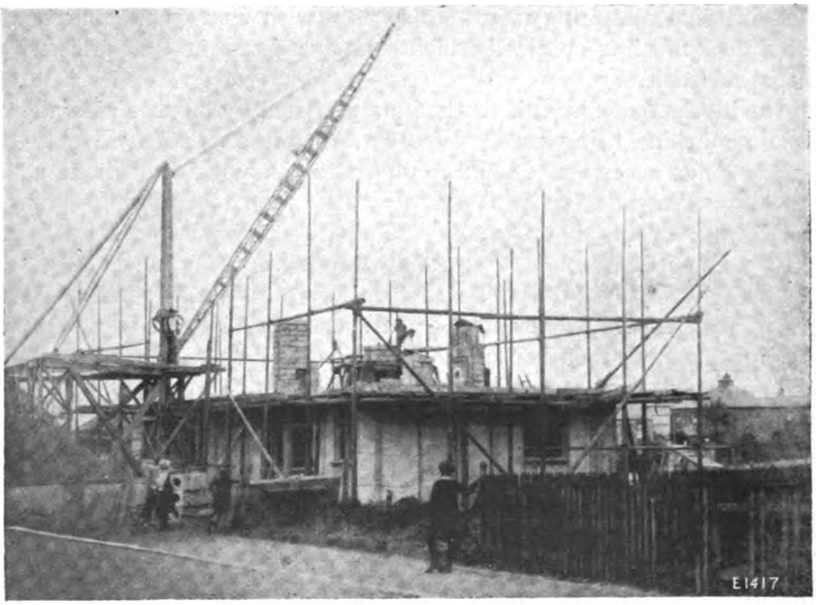
Many advantages are claimed for the Bravin patents, which have been acquired by the above Company, and which are extensively used in their system. For example, the whole of the flues in their buildings are erected in "Bravin" patent fire-resisting concrete. Special blocks have been designed by means of which all the necessary bends can be made. Furthermore, by means of its use internal plastering may be dispensed with, and when combined with sawdust a floor finish is obtained which compares favourably in price with the more usual methods.

All the blocks made by this method are prepared by hand in specially made moulds, no machine being used. In order, therefore, that there may be no cutting it becomes necessary to build to multiples of a block throughout, a special set of working drawings has consequently to be prepared from the plans submitted. Such a sheet is shown in connection with a trial house which is in course of erection for the Board of Agriculture at Amesbury. (*Fig.* 2).

The houses which are now being built in Hertfordshire, the first 16 of which it is hoped will be completed and ready for occupation in 12 weeks, are most economically planned, each house containing a dining-room, a study, a kitchen, four bedrooms and a bathroom, all within a superficial area of a little over 600 sq. ft. The elevations, it will be noticed, have a most pleasing appearance, the touch of brickwork about the porches and stacks giving just that added interest which is so desirable, but which the enthusiastic concrete designer so often despises, much to the detriment of the general appearance.

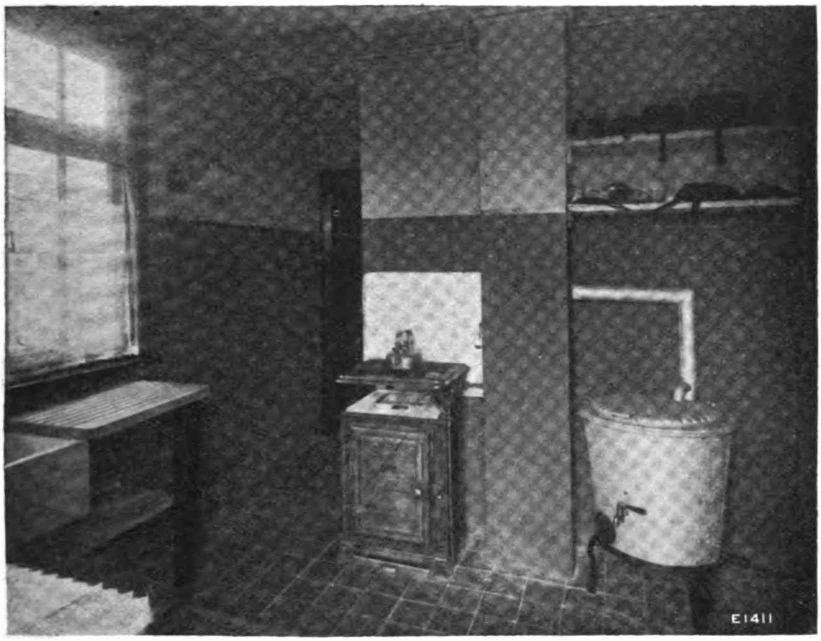
### HOUSES AT PARKSTONE, DORSET.

The fact that the first cottages to be completed under the Government housing scheme are claimed to be those erected at Parkstone, Dorset, for the Poole Corporation under the Waller system of concrete construction, should do much to remove the last faint vestige of obloquy, which remains in the mind of some in connection with this material for cottage building. The Waller system of construction, which is an invention by Major J. A. de W. Waller, D.S.O., manager of the housing department of Messrs. Hill, Richards & Co., was devised with the object of relying as far as possible upon mechanical means of erection, thus reducing to an absolute minimum the use of skilled trades, which are both scarce and costly, upon the site. The walls, the floors, and the roofs are of reinforced concrete, and the entire method is a departure from the usual procedure of building. In order to centralise the work and to standardise it with a view to mass production, the parts are made in depots, which are set up in various centres around which work is being carried out. So that it may be possible to make these parts large, the plant on each job comprises a specially designed crane, by means of which the parts are lifted straight into place, when a small amount of *in situ* concrete is used, which unites the whole into a monolithic framed structure. A distinct advantage in this method accrues from the fact that as the depots are roofed, the usual inevitable delay which results from bad weather is to a large extent overcome. The inventor claims that the buildings erected by this method are everlasting, and that upkeep is reduced to a minimum ; that they are weather, vermin and fire proof. Furthermore, since the houses are light, transport is saved. Erection is speedy, and the necessary material is available in large quantities. The houses are cheap, costing from £770 to £815, and can be turned out at the rate of 4,000 in a year, the time of erection being only four weeks per house.

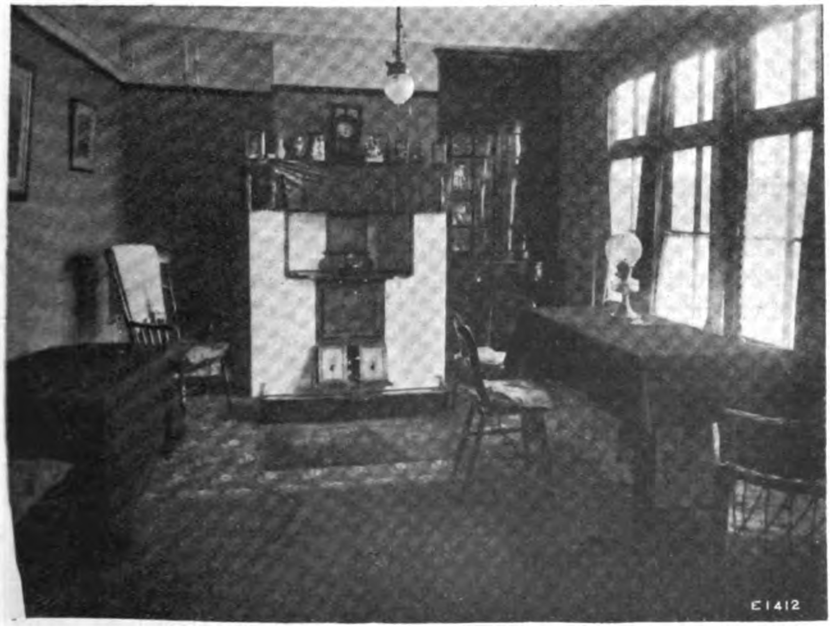


Houses in Course of Construction for the Poole Corporation, Parkstone.

The walls are formed by two slabs, separated by a cavity ; these slabs are connected at intervals with columns. Between the slabs, at ceiling level, wall-plates are formed, which carry the first-floor joists. The outer slab is formed of very high-grade reinforced concrete mixed " wet," while the inner slab is from porous concrete, of which the aggregate is crushed clinker. An interesting feature is that all the slabs are cast the full height of the storeys in one piece. The roof, too, is made in sections reaching from eaves to ridge, so that there is no horizontal joint. The vertical joints are covered by a reinforced concrete capping, due allowance for expansion and construction being made. In this way the chances of a leaky roof are minimised ; similarly the cost of repiars is negligible, there

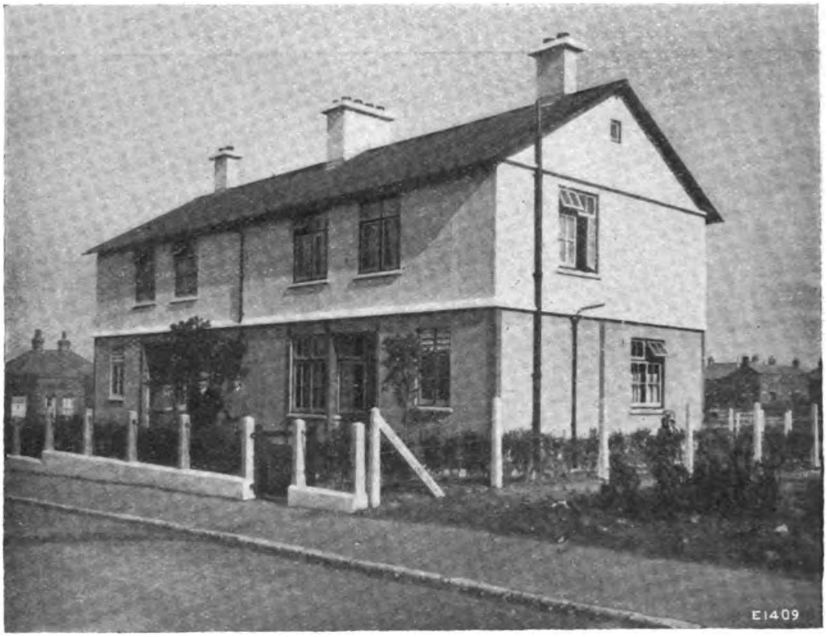


**Scullery.**



**Living Room.**

**HOUSES FOR THE POOLE CORPORATION AT PARKSTONE.**



View of Complete Houses.
HOUSES FOR THE POOLE CORPORATION AT PARKSTONE.

being no tiles to become displaced or timbers to rot. The chimneys are formed of a special block made of breeze concrete. These blocks weigh up to 1 ton each. The floors are formed of pre-cast blocks, in which the joist and floor are in one piece, a variety of floor surfaces may be used, such as granolithic or tiles, linoleum glued into place, or ordinary floor boards fixed to light grounds. The underside of the slabs of the first floor form the ceiling of the ground floor, and the same applies to the attic slabs, which are made of the same strength. Access is provided to the attic, which, owing to the absence of collar-beams, forms a very useful space for storage. In the houses at Parkstone the window frames are of wood, but it is intended to manufacture a concrete frame in which the metal casements will be already cast previous to building in.

The elevations are very simple ; the roofs may be hipped if desired, and they may be of various textures and colours. Those at Poole are a rich brown colour. Similarly the surface of the walls may be subjected to a variety of treatments, either in course of manufacture or subsequently.

The houses at Poole are parlour type, and an idea of the accommodation may be obtained from the photographs which show the principal rooms. The houses have been occupied since the first week in September, and are proving satisfactory in every way, particularly in regard to those matters concerning which it has been so insistently claimed that concrete construction would never prove successful, such as moisture through condensation, and resilience due to the thinness of the walls and floors. Those who still have doubts as to the efficacy of concrete cottage construction would indeed be well advised to visit these houses at Parkstone, in order that some, at least, of their fears may be dispelled.

# REINFORCED CONCRETE BUNKERS AND WATER TOWER.

*In addition to the many purposes for which it is the only practical, or even possible, material, reinforced concrete in all its various applications is being more and more extensively used purely on the grounds of efficiency and economy. In the examples which we describe herewith of coal storage bunkers, coal mixing bunkers and water towers, reinforced concrete was chosen in preference to steel or other methods of construction owing to the speed with which the work could be carried out and the saving in cost.—ED.*

## REINFORCED CONCRETE COKE OVEN AND BY-PRODUCT PLANT.

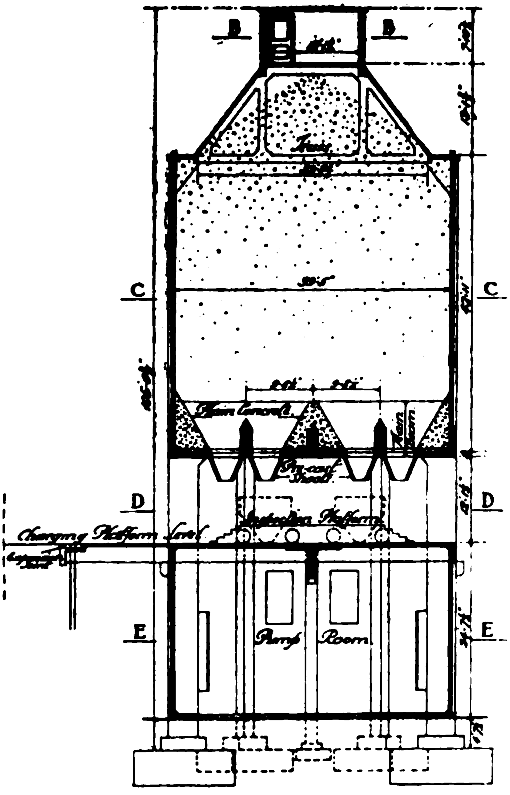
THE work here illustrated and described was carried out during the war in connection with coke oven and by-product plants erected in this country by the Coppée Company (Great Britain), Limited, of King's House, Kingsway, London, W.C., and the plants were designed by their engineers. The firm were so satisfied with the cost of the reinforced concrete work they have themselves erected that they have organised a separate department to deal with outside inquiries.

## BUNKERS AND WATER-TOWER AT SCUNTHORPE.

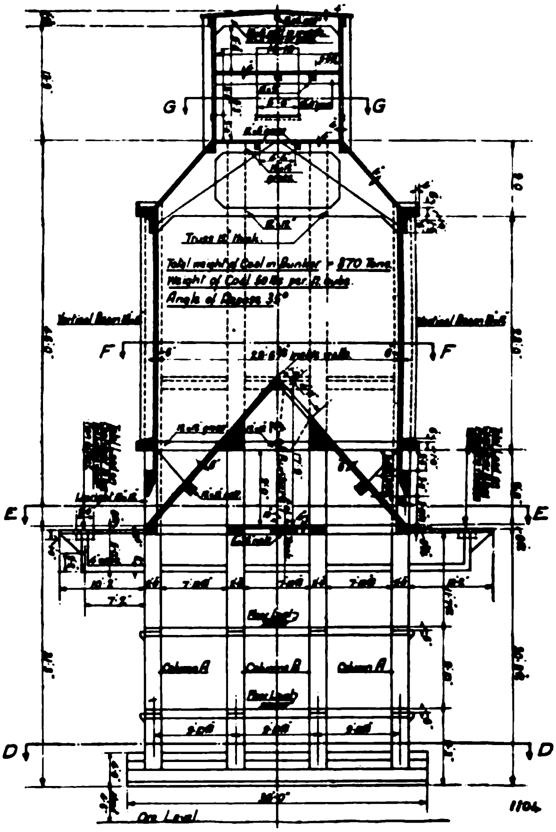
In connection with the extensive works carried out for the Redbourn Hill Iron and Coal Co., Ltd., at Frodingham, Scunthorpe, Lincs., the following parts of the plant were constructed of reinforced concrete :—1,000-ton coal storage bunker ; 1,000-ton coal mixing bunker ; 55,000-gallon water-tower ; water softening tower ; breeze bunker ; and shale bunker.

1,000-*ton Coal Storage Bunker.*—When washed, crushed and drained, the coal is elevated to the top of the bunker and distributed into it by means of a conveyor. The trams run underneath the bottom of the bunker and receive loads for conveyance to the coke ovens. In cases where the coal has to be stamped before being put into the ovens, it is discharged at the sides of the bunker. The arrangement of the columns was dictated by the necessity for a clear width of 49 ft. 6½ in. between the same, to allow the ram engine and stamping machine to pass. It was, therefore, necessary to adopt an unusual form of construction. On either side of the bunker there are cantilever brackets which support the two stamping stations. The sizes of the concrete members are shown in our illustrations. The two large braced beams are specially interesting, as they each carry a load of about 500 tons over a clear span of 49 ft. 6½ in. The concrete used consisted of 4 parts granite chippings, 2 parts sand and 1 part Portland cement ; indented steel bars were used throughout for the reinforcement.

1,000-*ton Coal Mixing Bunker.*—This bunker is used to mix the coal before it is prepared for the ovens. The structure consists of a machinery section at one end, and six separate bunkers containing together 1,000 tons when full. Owing to the nature of the ground, it was necessary to construct a mass concrete raft over the side before commencing the reinforced concrete work. All the reinforcement consisted of indented bars. The reinforced concrete foundations consisted of strip footing varying in width from 2 ft. to 5 ft. 6 in.; the beams vary from 12 in. to 20 in., but are all 60 in. in depth. Each strip footing supports a pair of columns. The main columns vary from 20 in. by 20 in. to 28 in. by 20 in. On the ground level a series of beams support the mechanical apparatus and the brick filling walls, the beams being generally 12 in. by 9 in. and 18 in. by 9 in. The hoppers are 21 ft. 6 in. long by 12 ft. 3 in. wide by 12 ft. 3 in. deep; the walls are 5 in. thick stiffened by 12 in. by 12 in. beams running longitudinally between the gussets



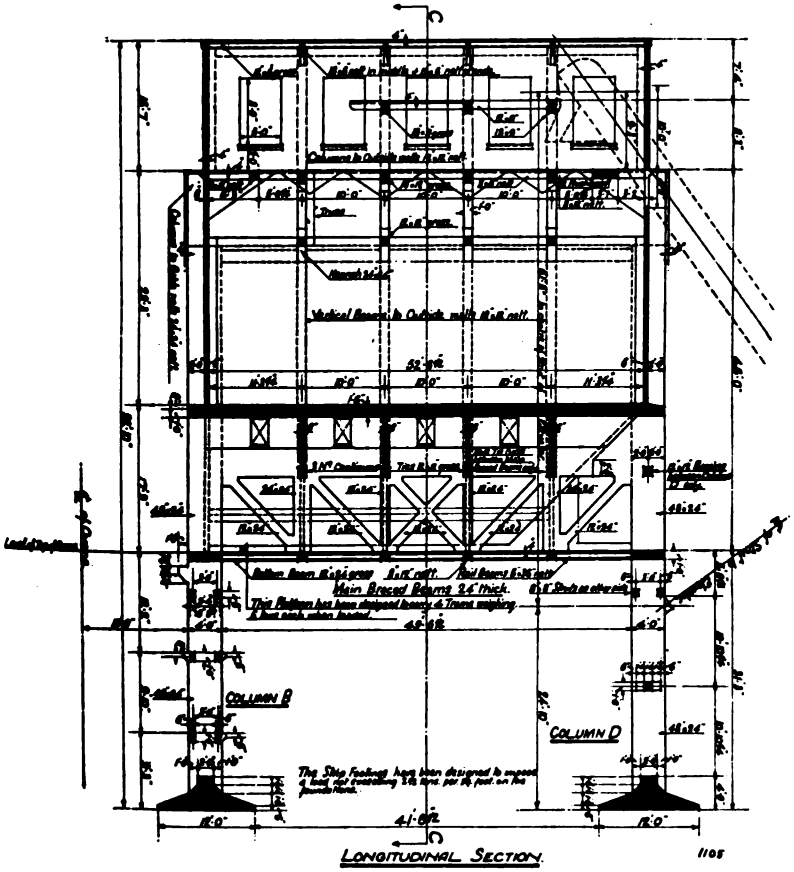
Cross Section.
1,000-ton Coal Storage Bunker at North's Navigation Collieries, Tondu, Glam.



1,000 ton Coal Storage Bunker at Scunthorpe.

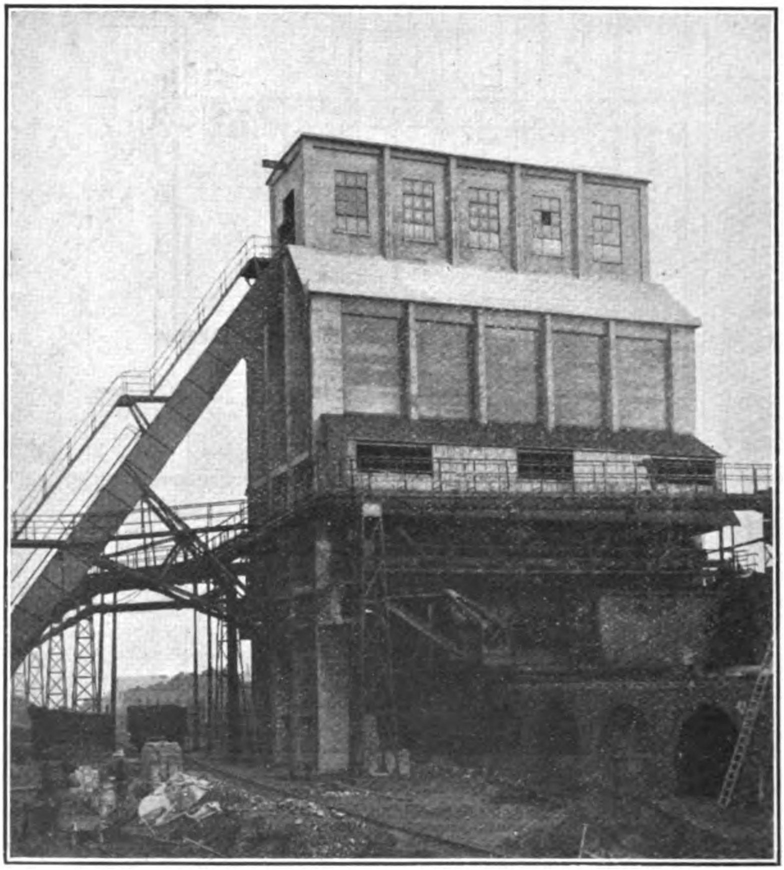
(4 ft. by 4 ft. by 9 in.) provided to brace the structure against wind pressure. The outside walls of the bunker are 8 in. thick at the bottom, tapering to 4 in. at the top. The division and end walls taper from 9 in. at the bottom to 4 in. at the top, and are stiffened by vertical beams 36 in. by 9 in. gross. The sloping roof is 4 in. thick. The superstructure floor is 3 in. thick, and is carried by 8 in. by 5 in. and 6 in. by 5 in. beams and by the division walls. The walls of the superstructure vary from 7½ in. to 3 in. in thickness. The flat roof is 4 in. thick, and is carried on 12 in. by 5 in. and 9 in. by 5 in. beams. The concrete is composed of a 4 : 2 : 1 mixture throughout.

55,000-*gallon Water Tower*.—This water tower, which was also constructed in connection with the coke oven and by-product plant at Scunthorpe, is 105 ft. 8 in. in height, the foundations being carried down 10 ft. below the ground level. The structure is of concrete throughout, reinforced with indented bars. The reservoirs consist of outer and inner circular tanks, one for hard and one for softened water. The foundations rest on the ore, and are composed of strip footings, 6 ft 6 in. wide. The beam to the footings is 42 in. deep by 12 in. wide, and the cantilever slabs on either side taper from 15 in. to 4 in. The supporting columns are 20 in. by 20 in. throughout. The pump-room is situated at the base of the tower, and the walls of this building stiffen the lower portion of the columns. The roof of this room is composed of a 4 in. slab, carried on 18 in. by 6 in. main and 10 in. by 5 in. secondary beams. Above the roof of the pump-room the columns are stiffened with 18 in. by 6 in. outside and 14 in. by 6 in. inside braces, the former being haunched to add to the stiffening. Platforms are provided on these braces to give access to the pipe joints, the platforms being reached by ladders provided with safety guards. The floors of the tanks are composed of a 6 in. slab, carried by three beams, each 20 in. deep by 12 in. wide. These beams



1,000-TON COAL STORAGE BUNKER AT SCUNTHORPE.

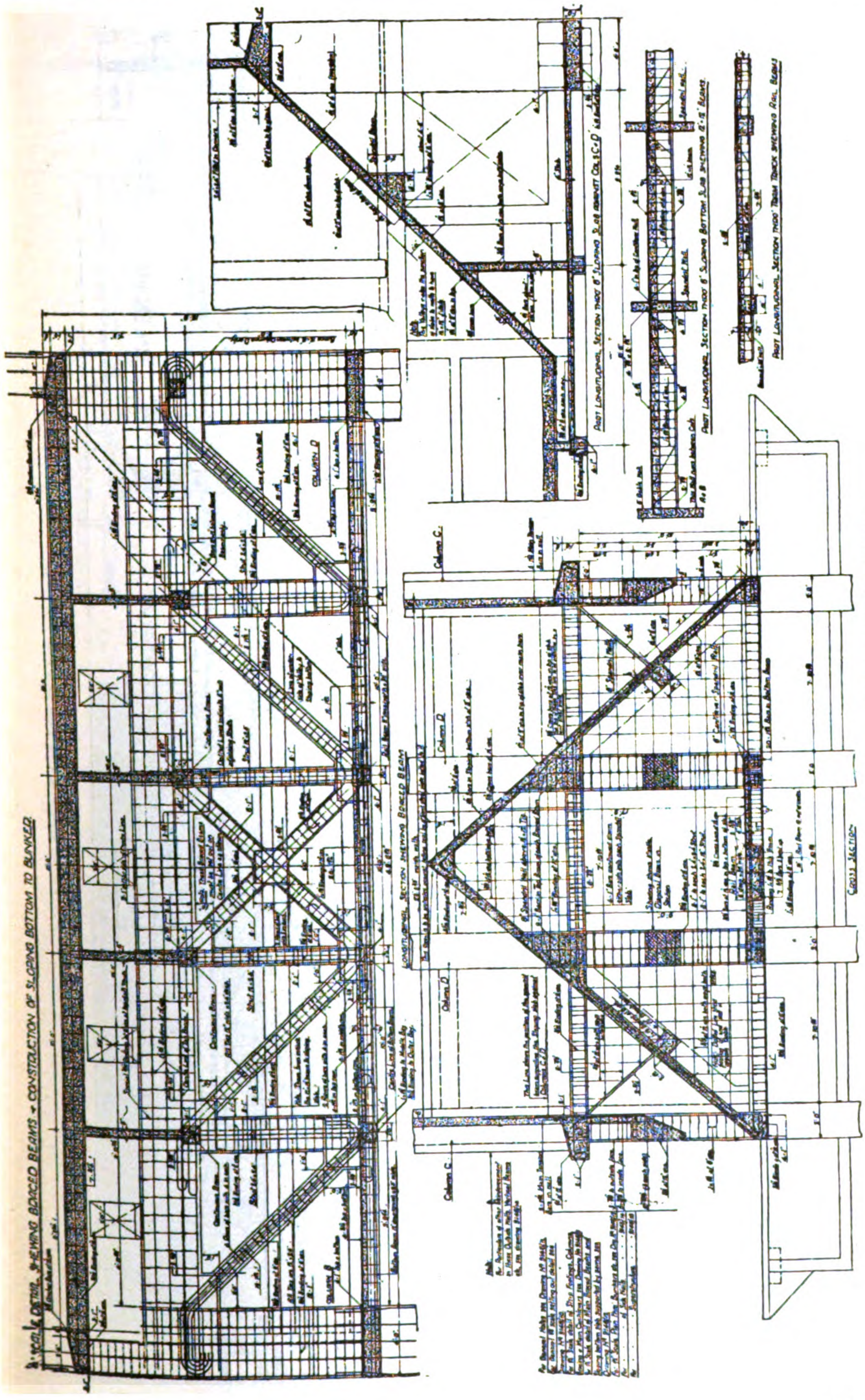
are haunched against the columns, and continue beyond in the form of cantilevers. A 12 in. by 12 in. stiffener runs round from column to column. The tanks are 19 ft. 8 in. deep., the inner diameter of the outer tank being 24 ft. 10 in., and that of the inner tank 17 ft. 2 in. The walls of the outer tank are 6 in. thick, with 6 in. by 6 in. fillets at the base; the walls of the inner tank are 5 in. thick, and also have 6 in. by 6 in. fillets at the base. A platform at the top of the tank is made of a 4 in. slab and a 12 in. by 4 in. beam. The concrete mixture used consisted of four parts granite chippings, two parts sand, and one part Portland cement. The maximum pressure on the foundations is estimated at about two tons per square foot, under a maximum wind pressure of 30 lbs. per square foot.



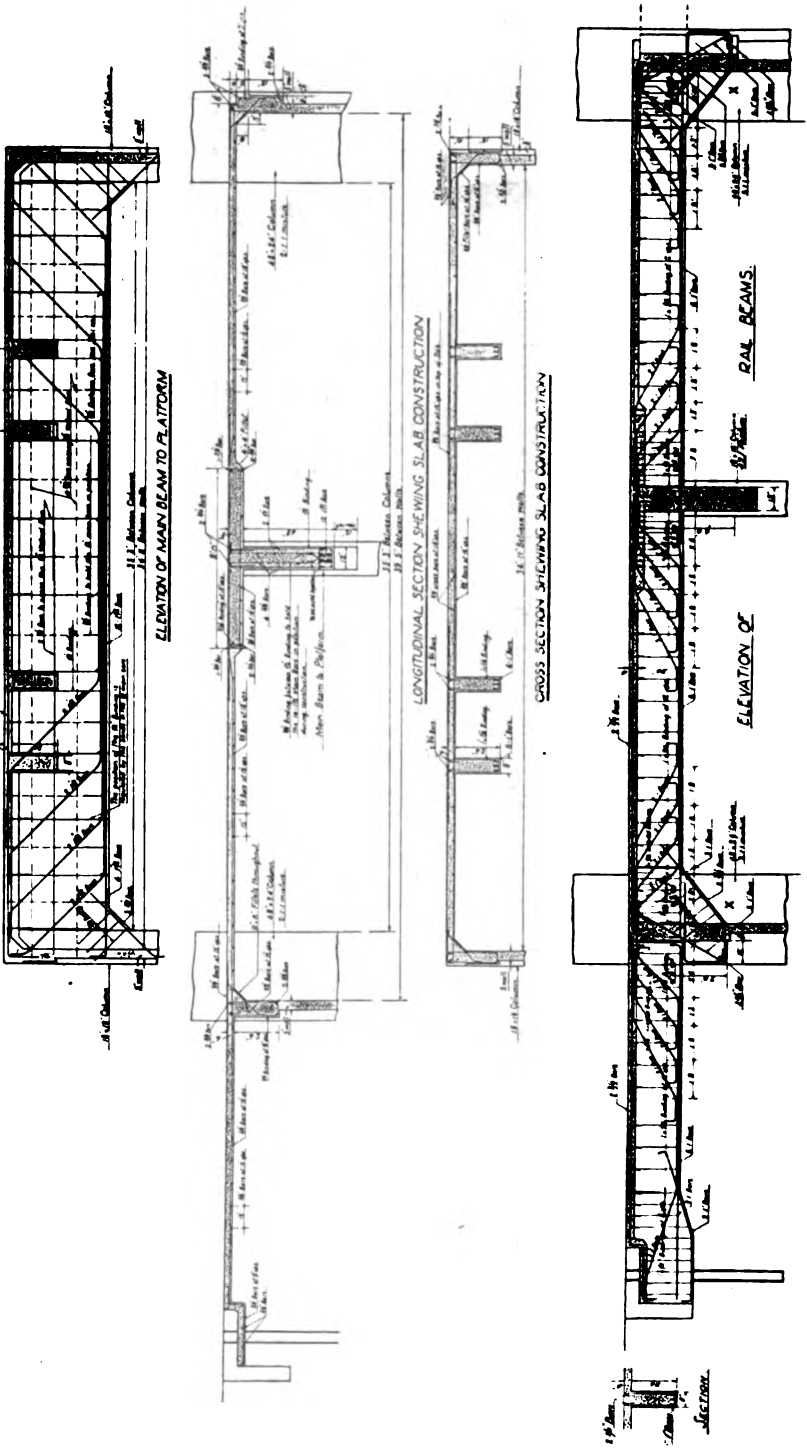
1,000-TON COAL STORAGE BUNKER AT SCUNTHORPE.

### 1,000-TON COAL STORAGE BUNKER AT TONDU, GLAMORGANSHIRE.

This large bunker was erected for Messrs. North's Navigation Collieries (1889), Ltd., at Tondu, Glamorganshire, to receive the washed coal and deliver it to the trams which feed the coke ovens. This bunker, which is circular in shape, contains 1,000 tons of coal in a single compartment. The bunker is supported on six main columns, two of which are 48 in. by 24 in., and the remainder 24 in. by

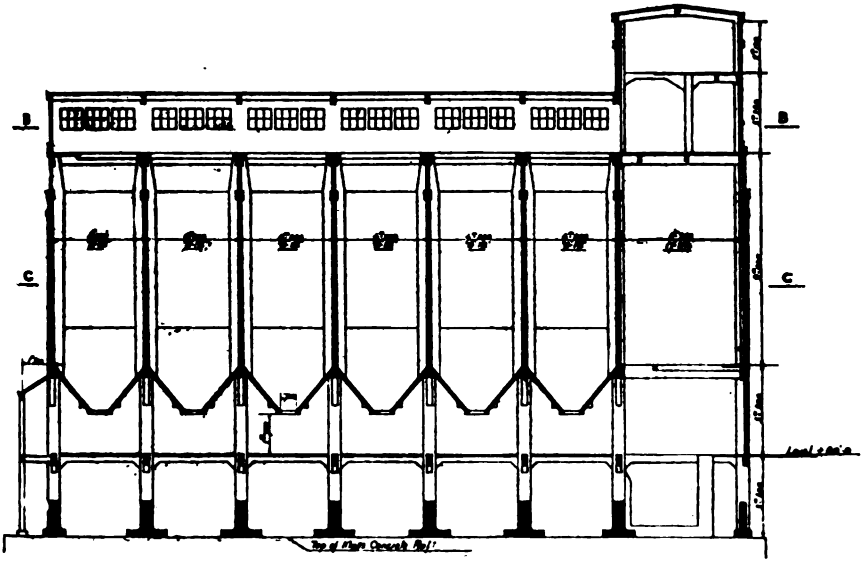

ELEVATION & DETAIL SHEWING BOXED BEAMS + CONSTRUCTION OF SLOPING BOTTOM TO BUNKER
LONGITUDINAL SECTION SHEWING BOXED BEAM
PART LONGITUDINAL SECTION THRO' 6" SLOPING SLAB AGAINST COLS C-D
PART LONGITUDINAL SECTION THRO' 6" SLOPING BOTTOM SLAB SHEWING 12"×12" BEAMS
PART LONGITUDINAL SECTION THRO' TRAIN TRACK SHEWING RAIL BEAMS
CROSS SECTION
Column C
Column D

1,000-TON COAL STORAGE BUNKER AT SCUNTHORPE.

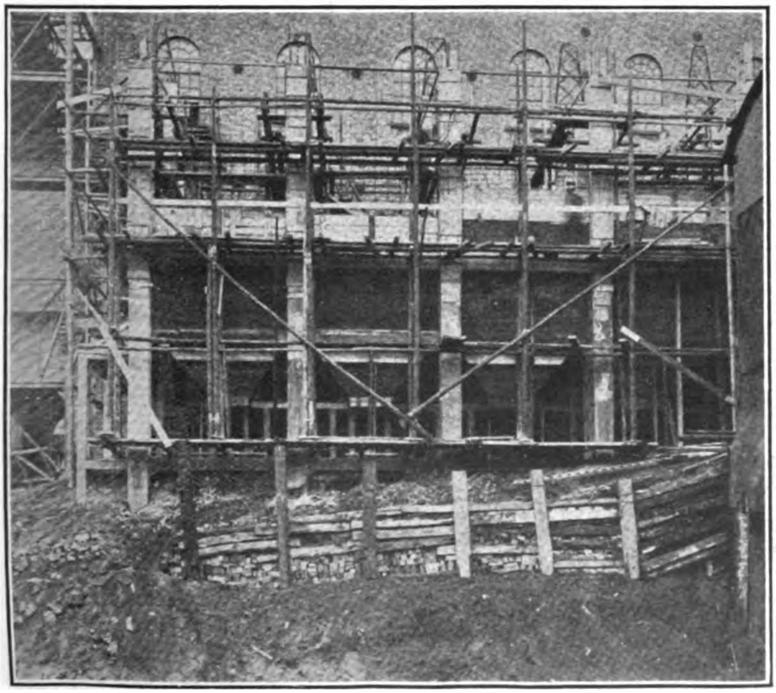

ELEVATION OF MAIN BEAM TO PLATFORM
LONGITUDINAL SECTION SHEWING SLAB CONSTRUCTION
CROSS SECTION SHEWING SLAB CONSTRUCTION
ELEVATION OF RAIL BEAMS.
SECTION

1,000-TON COAL STORAGE BUNKER AT NORTH'S NAVIGATION COLLIERIES, TONDU, GLAM.
Working Drawing of Tram Platform

24 in. These columns have reinforced concrete footings 6ft. 6 in. square by 2 ft. deep and 4 ft. 6 in. square by 2 ft. deep respectively. Under the footings and columns is a mass concrete foundation 16 ft. square to the larger columns, and 11 ft. square to the smaller columns. Two smaller columns, 18 in. by 18 in., extend up-

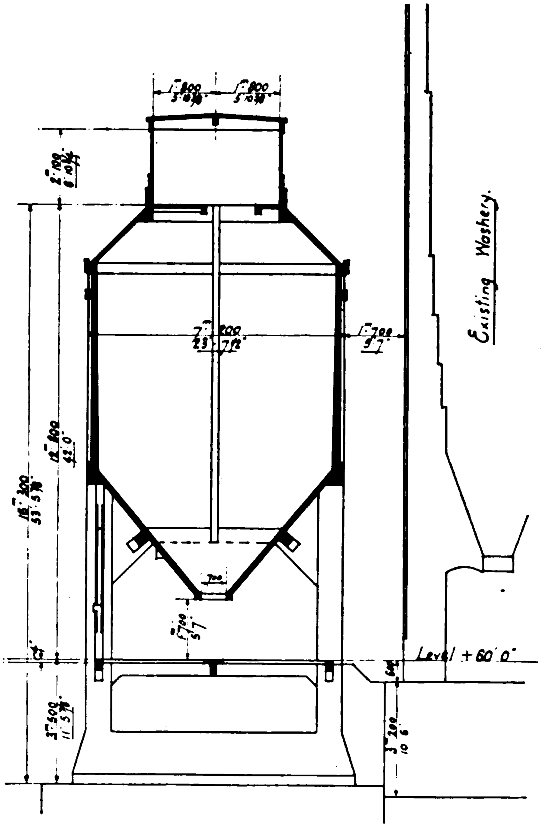


Section GG.
1,000-ton Coal Mixing Bunker at Scunthorpe.



1,000-ton Coal Mixing Bunker at Scunthorpe.

wards to carry the main beams of the tram platform. Under the tram platform is a pump-room, the walls of which are 5 in. thick, resting on a foundation slab 4 ft. wide by 6 in. thick. The tram platform is carried by a main beam 48 in. deep by 12 in. wide, with a clear span of 33 ft. 3 in. between columns; a tee, 96 in. wide by 8 in. thick, takes the compressive stresses. The tram rails are carried on beams, 3 ft. 7½ in. centre to centre, 24 in. deep by 8 in. wide. The deck slab is 4 in. in thickness. The bridge is of similar construction, but is provided with expansion joints owing to one end resting on the ovens.

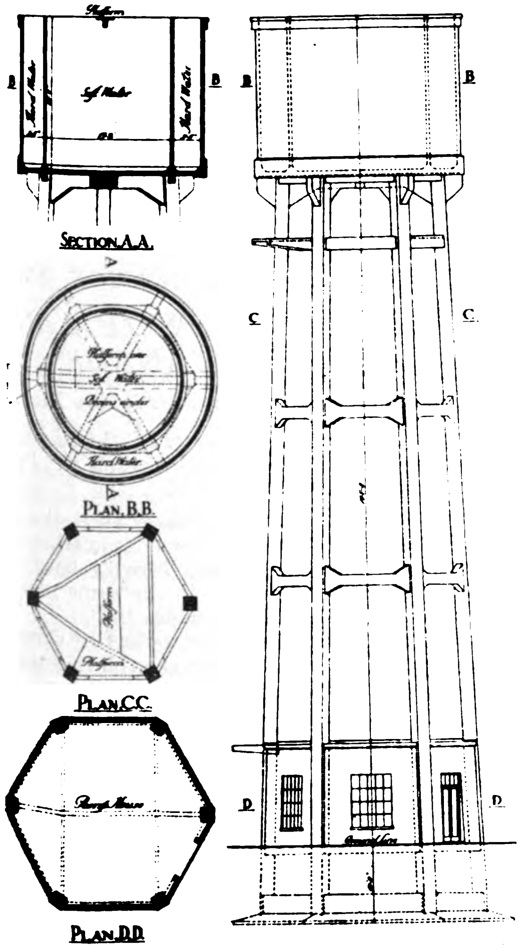


Section FF.
1.000-ton Coal Mixing Bunker at Scunthorpe.

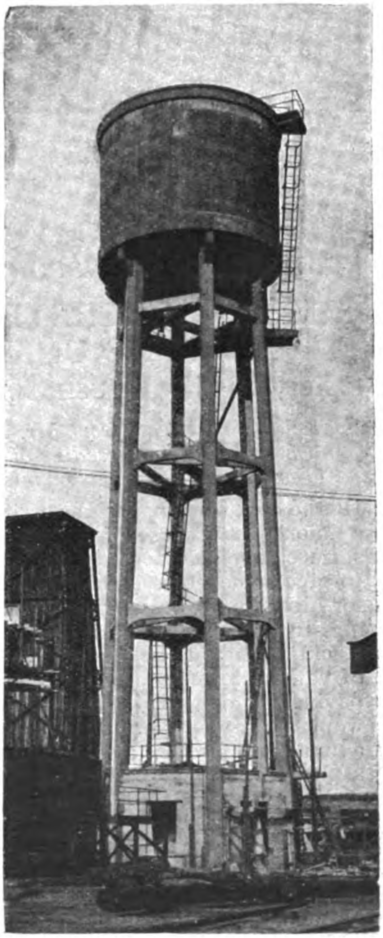
The bottom of the bunker is composed of a main beam 96 in. deep by 24 in. wide, secondary beams 48 in. deep by 18 in. wide, other beams 24 in. deep by 15 in. wide, and a 9 in. slab. The small hoppers, sixteen in number, are 4 ft 3 in. square at the top and 3 ft. 3 in. deep. These hoppers were moulded on the ground and afterwards erected into position, the projecting anchor rods being concreted into the main construction of the bottom.

The slopes to the openings are formed of mass concrete at an angle of 60 deg. A plinth at the bottom of the wall, 48 in. deep by 11 in. wide, serves to distribute some of the load on to the columns. The bunker is constructed of a 5 in. shell stiffened with six uprights, 24 in. wide by 11 in. deep. The internal diameter is

39 ft. 5 in., and the depth 42 ft. 11 in. A simple cornice has been constructed at the top of the bunker to form a finish to the walls. The superstructure is mainly carried on a reinforced concrete truss. This truss has a span of 39 ft. 5 in., is 14 ft. 2 in. deep, and is composed of 12 in. by 12 in. members; two beams, 18 in. by 12 in., carry the corner columns. The sloping slabs and walls are all 4 in. thick. The flat roof tapers from 5 in. in the centre to 4 in. at the edges. The floor of the superstructure is 4 in. thick, and is stiffened by 10 in. by 6 in. beams under the motor which drives the elevator.



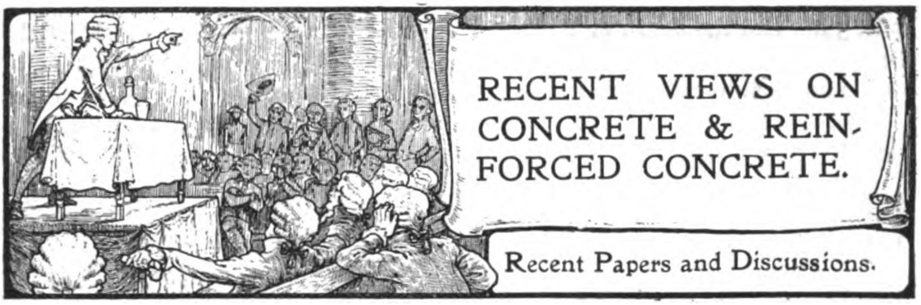
Elevators and Sections from Working Drawings.



View of completed Water Tower.

55,000-GALLON WATER TOWER AT SCUNTHORPE.

The concrete in the 48 in. by 24 in. and 24 in. by 24 in. main columns is composed of two parts granite chippings, one part of clean sharp sand, and one part finely ground Portland cement. This concrete continues at least 12 in. into all adjacent work of a poorer mixture. The remainder of the reinforced concrete is of a 4 : 2 : 1 mixture. Indented bars were used for all the reinforcement.



## RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

*It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.*

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### *ROADS AND TRANSPORT CONGRESS AND EXHIBITION* (1919).

# CEMENT CONCRETE PAVEMENTS IN NEW ZEALAND AND THE UNITED STATES AND CANADA.

**Paper by WALTER E. BUSH, M.Inst.C.E., etc., City Engineer, Auckland, New Zealand.**

*Following the abstract from Mr. Bush's paper we give a short report of the discussion which followed the reading of the two papers by Mr. Matthews Jones and Mr. Bush. For further comment on this question, see our Editorial Notes.*

IN the following paper the writer proposes to outline his personal experience and opinions on the use of Portland cement concrete as a combined foundation and surface pavement for urban traffic streets in the City of Auckland, New Zealand, and to give some notes of his observations on the use of concrete in the same manner for highway purposes in the United States and Dominion of Canada.

In the course of his official duties the writer submitted a report to the City Council, Auckland, upon the streets of the city, dealing, *inter alia*, with the relative merits of various forms of paving, in which he stated his belief in the future of concrete paving for climates like that obtaining in Auckland, especially as motor traction would tend more and more to replace horse traction in the future, and in respect to a number of streets he gave alternative estimates for paving such streets in compressed asphalt, wood block, stone setts and concrete. It was not, however, until the latter end of 1915 that the City Council authorised him to put down the first cement concrete pavement in the city, although cement concrete foundations had been put under all paved streets. The measure of success met with in the first street has led to its increasing use, and practically all streets that have since been permanently paved have been carried out in cement concrete, and when the writer left New Zealand in March last some 35,000 yards in all had been completed, 14,000 yards were in hand, and an additional 135,000 yards had been authorised.

The first street to be paved was *Little Queen Street*, 423 ft. in length, and lying almost due north and south, so exposing it to the sun's rays for the middle part of the day, which means in summer-time that the surface temperature is often as high as 120° F., and may sometimes exceed that. Its mean elevation is 9 ft. above sea level, and it serves the back or cart entrances of a number of warehouses and works to and from which traffic is of the heaviest description, both two and three-horse lorries and also motor trucks being used, carrying the largest loads that the very flat grades on the water front make possible, and it is also subjected to much turning and twisting traffic from the fact that many of the warehouses have cart docks, and practically all unloading is done by backing the lorries and trucks either into such cart docks or against the kerb.

### CONSTRUCTION.

The street was prepared for paving by scarifying the water-bound macadam, excavating to the required depth and preparing and rolling the sub-grade to the required camber to receive an uniform thickness of 8 in. of pavement, with a fall from the crown to the channel of approximately 1 in 36.

Two-coat work was adopted, the lower six inches of 7 to 1 concrete and the upper two inches of 3 to 1 concrete. The 7 to 1 concrete consisted of 5 parts of clean beach shingle having a fair proportion of sand, 2 parts of broken basalt between 1 in. and 2½ in. gauge, and 1 part of Portland cement, while the 3 to 1 concrete consisted of 2·25 parts of beach shingle, 0·75 parts of ¾-in. gauge basalt chippings and 1 part of cement. The top 2 in. was laid immediately after the lower 6 in. had been roughly brought to its proper shape, and while it was quite green, so as to ensure that the whole 8 in. was practically homogeneous.

The surface was brought to a proper camber by a straight timber template shod with steel, operated transversely to the longitudinal axis of the street, from the centre to the channel, on screeds of angle iron fixed to bars in the ground, after which it was steel trowelled till it presented a wet even surface; after setting had commenced it was lightly broomed to remove glazing of any portion of the surface, and when setting had taken place the surface was covered with bags and kept wet for eight or nine days.

It being midsummer, only three weeks was allowed before the paving was opened to traffic. It was then allowed to carry the traffic for nine months, before being treated with Californian asphalt, brushed on hot and dressed with screened beach shingle.

Prior to the application of the asphalt dressing the surface showed slight signs of wear in one or two places where the quality of the shingle had not been so good as in the remaining portions, a fact which emphasises the necessity of only using the best qualities of aggregate available in this class of pavement.

The next street (*Durham Street*) was done with one-coat work 7 in. thick of 5 to 1 concrete, the traffic conditions not being so severe as in the first mentioned, and it was left untreated and has stood quite satisfactorily since its completion in October, 1916.

The third street to be paved in concrete (*Park Road*) forms a portion of Auckland's busiest traffic outlet, and lies immediately eastward of the important reinforced concrete viaduct known as Grafton Bridge, which is surfaced with compressed Neuchatel asphalt.

It carries mixed traffic, most of which is fast travelling, and including heavy petrol motor wagons and chars-à-bancs, but no motor 'buses similar to those so common in London, the number of vehicles counted being over 2,000 per day of ten hours.

The work was done in two halves to prevent stoppage of the traffic, and was much delayed by difficulty in obtaining shingle owing to bad weather, and this resulted in some shingle being used which was not absolutely first class, and also in the street being opened up for traffic sooner than was advisable, and it caused the writer to cease using shingle for aggregate and to substitute therefor broken basalt and sharp sand.

The alteration was made during the progress of the Park Road job, which was a one-coat pavement of 5 to 1 concrete, 8 in. thick, and the bays done with the basalt and sand aggregate showed enough superiority to the rest of the work to justify his conclusion.

With the exception of a short length of the basalt and sand concrete, the whole surface was treated with a dressing similar to that used on Little Queen Street.

In all the streets paved since 1917 the paving has been one-coat work of concrete composed of clean basalt chippings and screenings varying from 1¼ in. gauge to " fines " mixed with 25 per cent. of sharp beach sand free from shell and gauged with Portland cement in the proportion of 5 of aggregate to 1 of cement, but prior to the concrete being laid the sub-grade is sprinkled with 2¼ in. clean basalt road metal as a measure of economy. In all cases the sub-grade is carefully prepared and rolled solid, and steel rod reinforcement is laid transversely over trenches likely to cause trouble by subsidence.

The accompanying schedule shows the works done to date :—

| Name of Street. | Length in feet. | Area in square yards. | Thickness in inches. | Cost per square yard, pavement only. | Date of completion. | Remarks. |
|---|---|---|---|---|---|---|
| Little Queen Street .. | 423 | 2,187 | 8 | 10/- | Feb. 1916 | See paper. |
| Durham Street .. | 212 | 390 | 7 | 9/- | Oct. 1916 | See paper. |
| Park Road .. .. | 650 | 2,984 | 8 | 9/- | July 1917 | See paper. |
| Market Roads .. | 640 | 1,340 | 7 | 8/- | Mar. 1918 | Untreated. |
| Exchange Lane .. | 140 | 155 | 4½ | 5/3 | Dec. 1917 | Untreated. |
| Quay Street Extension | 530 | 3,828 | 8 | 9/- | Mar. 1918 | Untreated. Intersected by railway sidings. |
| King's Wharf Road .. | 605 | 2,351 | 8 | 9/- | May 1918 | Untreated. Intersected by railway sidings. |
| Beach Road .. .. | 1,896 | 12,801 | 8 | — | May 1919 | Double-track tramway. |
| Anzac Avenue .. | 2,347 | 9,909 | 8 | — | — | Under construction in March, 1919. |
| Symonds Street .. | 3,100 | 13,427 | 8 | — | Sept. 1919 | Double-track tramway. |

Total length, 10,543 ft. Total area, 49,372 sq. yds.

In addition to the above an area of over 2,000 sq. yds. in Pitt Street, on which trial lengths of proprietary bituminous pavement had been laid on a 6-in. concrete foundation and had failed, was surfaced on the old concrete foundation with a rich concrete (3 to 1), half of the area being an average thickness of 3 in. and the remainder 3½ in. This was only completed in March last.

*Note :* The prices paid for labour and materials were as follows : Labourers 10s. 7d., finishers and machine men 11s. 7d. per day of 8 hours ; cement delivered 50s. per ton ; basalt chips and screenings 10s. 3d., basalt road metal, 2¼ in. gauge, 9s. 3d., and sand 10s. 11d. per cu. yd.

The concrete is mixed by machine, one gang using a continuous self-mixing type and the other a 7 cu. ft. batch mixer fitted with boom distributing hopper.

On the question of hand versus machine mixing the author has a decided preference for the latter, and is surprised that so few are being used for concrete work in street foundations in this country. In America their use is universal, and on both counts of economy and efficiency he would strongly advise their adoption.

Dealing with the much discussed question of joints, the writer has adopted the use of tarred paper, folded to form two thicknesses, and these are placed approximately 56 ft. apart, the length of bay laid being 14 ft., and four bays a convenient length for a joint.

Out of 35,000 yds. laid, of which only 5,216 had been coated, not a single crack had been discovered between the bays, and only in Little Queen Street and Park Road, in which shingle concrete was used, were there any noticeable signs of wear. The tarred paper joints and those formed by the junction of two bays are coated with asphalt and fine shingle.

In America cracks are often seen in concrete roads, but most engineers there do not attach any importance to them, but treat them with some sort of asphaltic filler.

Where concrete paving is laid in streets with tramway tracks, a longitudinal wall, 9 in. wide and as deep as the bottom of the tram track foundation, is put under the pavement 18 in. from the outer rail, to prevent disturbance of the pavement when the track, mostly laid on sleepers, is being packed or repaired. A stone sett margin is used to separate the pavement from the portion of road occupied by the tram track, which is surfaced with bituminous macadam, 2 in. thick, laid on water-bound macadam in the margins and between rails and well rolled.

The cross fall adopted is 1 in 36, unless special conditions necessitate a variation.

The method of finishing adopted has been similar to that used in the case of Little Queen Street, but now a belt is being used with good results.

Arising from his experience in carrying out concrete paving, the writer desires to emphasise the adoption of the following precautions :—

(*a*) The thorough preparation of the sub-grade or foundation, including the use of a suitable steel reinforcement over trenches or holes where subsidence may take place.

(*b*) The use of the very best quality and uniformity of aggregate and cement, and their thorough mixing, with as small a quantity of water as is necessary to ensure density of mass and smooth finish.

(*c*) The utmost care in the tamping, screeding and trowelling of the pavement.

(*d*) The keeping damp of the concrete during the process of setting and hardening.

(*e*) The allowance of ample time for setting—never less than three weeks in summer and four in winter or damp or cold weather, and preferably longer, before traffic is allowed to use the pavement.

***(To be continued.)***

***That portion of the paper dealing with information gathered in America will be reproduced in our next issue.***

## DISCUSSION.

Following the reading of the above paper and that by Mr. W. Matthews Jones, M.Inst.C.E. (of which we gave an abstract in our last issue), an interesting discussion took place, of which the following is a summary :—

**Mr. H. T. Chapman** (Kent County Council) said they were probably all agreed as to the merits of concrete and reinforced concrete for general work, but it had not yet been decided that concrete gave a good surface for roads. He thought that a resilient and elastic surface was desirable for all classes of traffic, but concrete did not possess these qualities. It was the practice in the United States to cover the roads with a surfacing of bituminous material, and the necessary resiliency would be obtained by this treatment, which would also prevent surface abrasion. Although expansion joints were necessary, too many of them became a source of weakness. In two-course work, there was the danger that the first course would take its initial set before the second course was applied, and therefore a poor cohesion was obtained. There was also the risk in the Hassam system that the large aggregates would be displaced under the shock of heavy traffic. Another argument against the use of concrete was the time it took to set, and it was a serious matter if while half a road was being re-made the other half had to take the whole of the traffic for twenty-eight days or so. This, of course, could be avoided by a temporary diversion of traffic, but he thought that the concentration of traffic had contributed to the failure of his own experiments. He had used river ballast as an aggregate, but owing to its roundness he did not think this material was as good for the purpose as broken stone.

**Mr. A. E. Collins** (Borough Surveyor and Engineer, Norwich) thought that the top reinforcement of a road was quite as important as the lower. In his opinion, a thinner layer of richer mixture was preferable to a thicker layer of two grades. On stable ground, the reinforcement should be at the top, and the concrete below would act as a pad ; also, with the reinforcement at the top any changes of temperature would be better resisted. He preferred a covering of a plastic material over concrete roads. If the costs of road-making were to be kept down, mechanical methods, such as were in use in America, would have to be more extensively used.

**Mr. L. Roseneave** (Borough Surveyor, South Shields) mentioned that in South Shields there were 20 miles of concrete roads on clay soil ; these roads were not reinforced and had been in existence for fifteen to twenty years. Although they have been in continuous use by traffic, including steam lorries, he did not think that concrete was suitable for steel tyres.

**Mr. J. A. Brodie** (Borough Surveyor, Liverpool) said he had come to the conclusion that concrete was the cheapest material for roads. The costs of road construction in Liverpool had increased above pre-war prices as follows :—Setts, 200 per cent. ; soft wood, 200 per cent. ; macadam, 100 per cent. ; concrete, 100 per cent. Concrete road foundations had been used in Liverpool since 1872, and he had constructed many concrete roads with coats of pitch mixture varying in thickness from 3 in. to ¾ in., according to the traffic the road was intended to carry. With regard to repairs, he thought it was better to use asphalt than to insert a layer of concrete. He deprecated the inaction of the local authorities of this country in the matter of investigations, and thought that engineers should be compelled by their local authorities to experiment with trial sections of roads.

**Prof. E. R. Matthews** (University College) described some experiments he had carried out to prevent concrete from cracking. In one case he had used two-course concrete, 8 in. thick, on a road on which other material had proved to be useless, and no cracks had appeared after five years' wear. Laths were inserted every ten feet and afterwards taken out and the spaces filled with bitumen. A mixture of 6 : 1 was used for the bottom course and 4 : 1 for the top. No reinforcement was used in this case, but he thought that reinforcement was often advisable, and should be laid two in. from the top. He had also experimented with reinforcement in concrete made with stone, gravel, clinker and slag aggregates to test their corrosive effect, and had found that cinder and slag were the worst, the steel becoming covered with rust, while in the case of stone and gravel the reinforcement was bright after two years.

**Councillor Rowlands** (Tilbury) said that in his area they had found that two-coat work was the best; granite chippings were used for the top layer and local gravel for the bottom, and this combination gave excellent results. One length of concrete road which carried very heavy traffic to and from the docks had cost practically nothing for maintenance, and they were so satisfied that they had decided to lay further reinforced concrete roads at a cost of £37,000.

**Mr. Max Clarke, F.R.I.B.A.,** agreed that the reinforcement should be at the top, as the steel rods or wires took the tensile strains and the concrete took the compression. The frequency with which roads were taken up and relaid was a great difficulty in connection with concrete roads in London. He urged the County Councils' Association to apply to the Government for a grant for the purpose of carrying out research work in connection with roads, and pointed out that such research work had been going on for years on the Continent.

**Mr. C. F. Gettings** (Highways Surveyor, Worcestershire County Council) stated that the Government had carried out experiments with roads before the war, but the results had not been published.

**Mr. J. W. Horton** (Surveyor, Derbyshire County Council) referred to the time which had to be allowed for concrete to set, and he thought this would be a great objection to its use for country roads.

**Mr. F. Wilkinson** described the concrete road he had put down when Borough Surveyor at Deptford; this road was not tarred, and after five months' wear the top coat where it had been floated was showing slight signs of wear at one place only.

In replying to the criticisms, Mr. Matthews Jones said that tar-spraying cost only about 2½d. per yd., and it was worth it for the protection it gave. Chiefly owing to the greater expense, he did not think two coats were desirable. He thought that better results would be obtained if the joints were put in at an angle of 40°, instead of straight across.

Mr. Bush said he did not believe in the two-coat system, and sometimes had put down a layer of broken metal first. In the United States, 600 sq. yd. per day were laid with the aid of mechanical mixers and good organisation. He used joints of two thicknesses of tarred paper every 50 ft., pasted over. In Auckland, he had laid 45,000 sq. yd. at an over-all cost of 12s. per yd. That was before the war, but labour and material in New Zealand then cost twice as much as in England.

At the conclusion of the meeting a resolution, that the conference was of the opinion that the question of the construction and maintenance of roads should be the subject of scientific investigation subsidised by the Government, was unanimously carried.

## MEMORANDA.

**Steel Ribs on Wide Concrete-Finishing Belt Prevent Warping.**—Wide belts for finishing concrete-road surfaces are considered by many engineers as preferable to narrow belts, but there has been great difficulty in keeping them from warping and digging into the finished surface. This difficulty has been overcome on one of the projects of the Maryland State Road Commission, by riveting steel ribs on the upper face of the belt.

The ribs are placed about 1 ft. on centres, and, for a distance of 1 in. back from the front, are bent upward about ¼ in. This keeps the front edge of the belt from digging the concrete surface. It is stated that this device has given a most satisfactory finish for concrete roads.

**Rapid Road Construction.**—The rapidity with which concrete roads can be constructed, and the value of labour-saving devices, was demonstrated by a recent achievement of the Mellon-Stuart-Nelson Co., of Chicago, whose record for one day's work in the laying of a nine-mile road in Illinois was 1,502 sq. yds. All the materials—sand, cement and gravel—were unloaded from trucks on a light railway by means of two derricks equipped with clam shells of 1 yd. capacity, and two mixers were used.

# THE ROADS AND PUBLIC WORKS EXHIBITIONS.

*It is several years since so many methods of concrete construction and concrete-making machinery have been brought together for public inspection as was the case in the Roads and Transport Exhibition and the Public Works Exhibition, which were held concurrently at the Royal Agricultural Hall, Islington, from November 20th to November 27th last year. Several systems of concrete road construction were shown in the former, whilst in the latter the stands were practically monopolised in the interests of concrete. As the exhibitions were visited by large numbers of representatives of local authorities and others interested in housing schemes, it was particularly gratifying to see the claims of concrete so prominently put forward. Most of the systems of cottage construction shown had been approved by the Ministry of Health, and will no doubt be as much in evidence when the housing schemes are commenced in earnest as they were in the erection of garden cities and houses for munition workers during the war. In view of the existing labour shortage in the building industry, there should be a great demand for such machines as concrete mixers and pressure block-making machines, practical demonstrations of many of which were given daily. Both from the point of view of the number and variety of the exhibits and the attendance, the Exhibitions were very successful.*

*The following are brief descriptions of the exhibits of more particular interest to our readers.—ED.*

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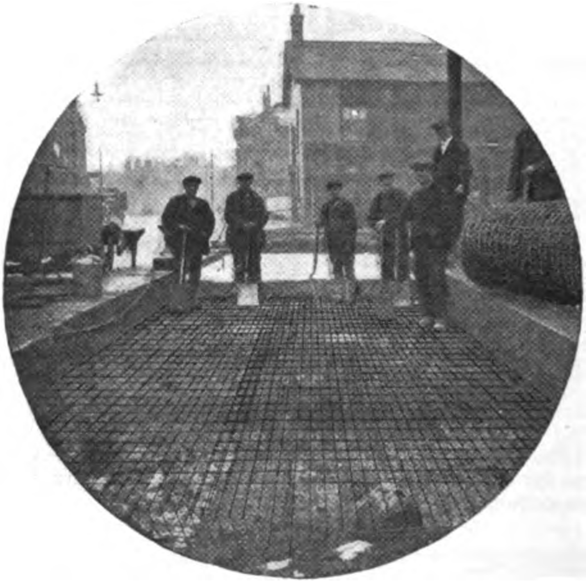
## ROADS AND BUILDING CONSTRUCTION.

The Stand of the *Expanded Metal Co., Ltd.*, contained samples of expanded steel sheet reinforcement for concrete roadways, foundations, walls, etc.; expanded metal lathings for plaster ceilings and partitions; "Exmet" reinforcement for brickwork, and wall ties. The feature of expanded metal is that it is a network formed from one sheet of solid metal, and therefore all the strands or members are rigidly connected. The material is supplied in flat sheets, the meshes of which interlock into each other where the sheets overlap at joints so that the reinforcement may be continuous over

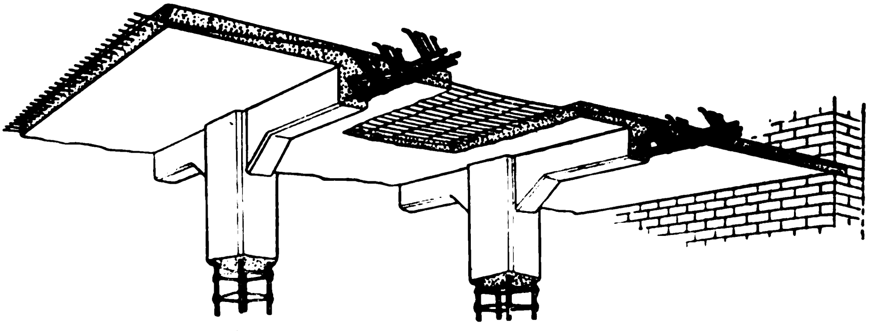
EXPANDED METAL ROAD REINFORCEMENT.

large areas. It is claimed that expanded steel distributes the stresses placed upon it in all directions, and that loads do not merely affect the concrete immediately beneath them. The mass of concrete is effectively bound together, and each mesh so encloses the concrete within it that directly the steel is stressed the concrete is compressed.

*Messrs. Johnson's Reinforced Concrete Engineering Co., Ltd.*, displayed their " Lattice " system of reinforcement for road, floor and wall construction, and the " Keedon " system for beams, columns, piles and general constructional work. The " Lattice " is delivered in the form of a complete fabric of any required length and up to 7 ft. in width, and the necessity of setting and spacing is dispensed with, with a resultant economy in labour and supervision. The " Keedon " reinforcement for columns consists of upright bars connected by wire hoops. After being looped round the uprights, the hoops, which take the diagonal tension and shear stresses, are locked with a wedge, thus ensuring their rigidity. In the " Keedon Bar " for beams, etc., the stirrups are locked in position by the same method, and possess the advantages of being both non-slipping and adjustable. Our illustration admirably demonstrates the combined use of the " Lattice " and " Keedon " systems of floor, beam and column construction.



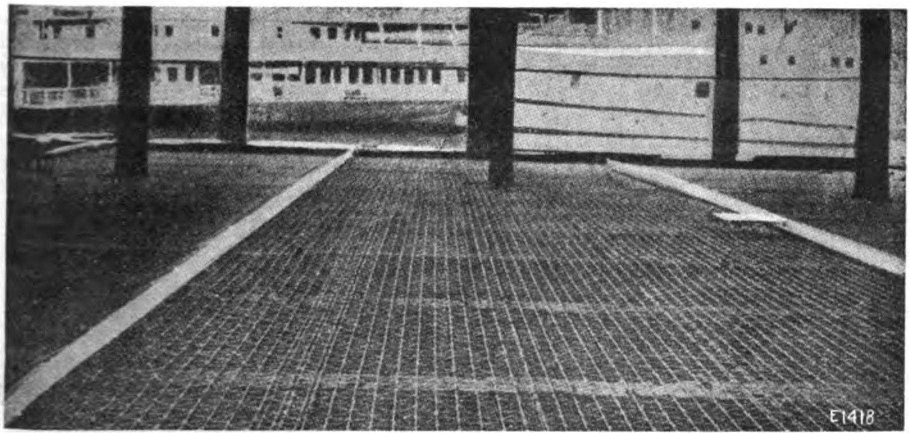
ROAD AT BURY REINFORCED WITH JOHNSON'S STEEL WIRE LATTICE.



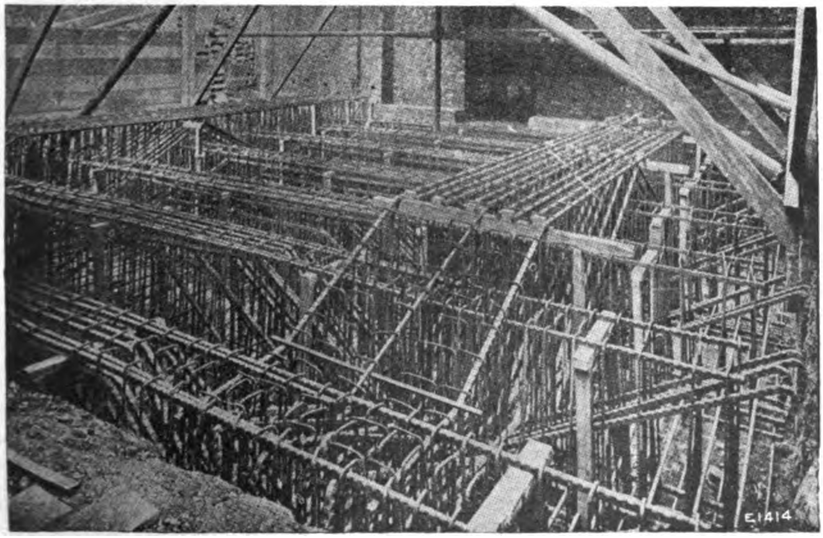
" LATTICE " AND " KEEDON " SYSTEM OF FLOOR, BEAM, AND COLUMN CONSTRUCTION.

" Poilite," shown by *Messrs. Bell's United Asbestos Co., Ltd.*, is an artificial stone made of Portland cement and asbestos. It is made in the form of flat and corrugated sheets and roofing tiles, and a system of cottage construction with the use of " Poilite " building sheets has been approved by the Ministry of Health for use in connection with housing schemes. The material is produced in thicknesses of $\frac{3}{16}$ in. and $\frac{1}{4}$ in., and of various sizes. Layers of cement and asbestos are uniformly distributed and compressed in rolling mills, the result being a tough, fire-resisting, woven fabric, which does not require painting or other treatment for its preservation. The corrugated sheets are recommended for roofs and external walls of factory buildings, and the flat sheets for internal partitions and ceilings. The tiles are made in two shapes —the standard diagonal tiles and the Roman type tiles.

*The Indented Bar and Concrete Engineering Co.* showed samples of their " Triangle Mesh " reinforcement, indented bars, and specimens showing two methods of reinforcing roads. " Triangle Mesh " is of the truss form of construction, and the cold-drawn steel wire with which it is made is claimed to have a tensile strength of



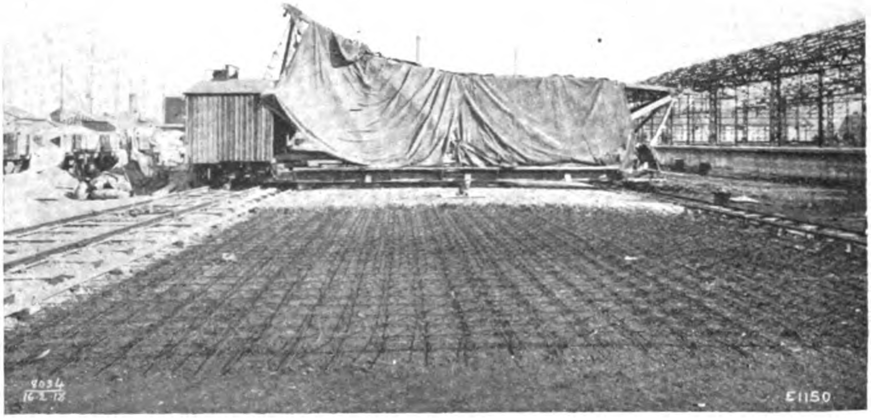
TRIANGLE MESH REINFORCEMENT FOR CONCRETE SLABS.



INDENTED BAR REINFORCEMENT FOR FOUNDATIONS.

85,000 lb. per sq. in., and an average elastic limit of 50,000 lb. per sq. in. A further advantage is that, owing to the cross wires being hinged to the main rods, the material can be folded on any longitudinal member without bending the cross wires. Should a top and bottom reinforcement be required, the hinged system permits of alternate longitudinal members being raised, and thus a zig-zag top-and-bottom reinforcement is obtained with only one layer of mesh. Our illustrations show a typical example of floor construction with " Triangle Mesh," and indented bar reinforcement for the foundation of a large building. The mesh is supplied in lengths up to 300 ft. and up to 56 in. wide.

*The Walker-Weston Co., Ltd.*, exhibited three specimens of their patent " Pyramidal " concrete reinforcement, viz.: (1) interlocked metal reinforcement, consisting of top and bottom layers of bars connected together with zig-zag inclined bars, which form pyramids of diagonal tension members combined with an interlocking arrangement. These bars radiate in various directions and provide the necessary resistance to the tension stresses; (2) a section of cellular reinforced concrete walling, on the same system; and (3) a concrete pad sleeper for use on railways. The " Pyramidal " interlocked reinforcement is claimed to be specially adapted to road construction, as no expansion joints are required. This is a point of great importance, as expansion joints are a continual source of trouble owing to the plastic material with which they are filled becoming clogged with stones, etc., and thereby rendered useless for the function they are intended to perform. The reinforcement is assembled upon the site, and is rigid and easily handled. It has also been found economical for wall construction, and walls have been built on this principle without the use of wood or other framework, the concrete being temporarily held in position by canvas. Hollow walls as well as solid can be erected with the use of this reinforcement, the cores consisting of triangular boxes, around which the concrete is punned. The wall is built in layers, and the boxes removed for re-use when the concrete is partly set. The system is also applicable to the construction of solid or hollow concrete girders or posts, and is being extensively used by the Port of London Authority. We illustrate a platform at the Victoria Dock constructed by this method. The system as applied to road or floor construction was fully described and illustrated in our issue of November last.



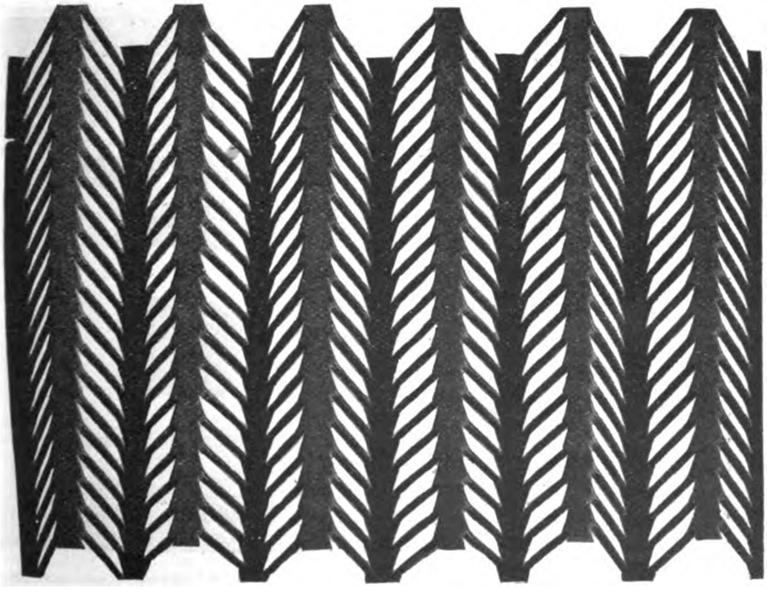
PLATFORM IN COURSE OF CONSTRUCTION WITH PYRAMIDAL REINFORCEMENT.

*Messrs. Tarmac, Ltd.*, in addition to their well-known tar-macadam road-making material, exhibited samples of " Vinculum " concrete building blocks, samples of the aggregate from which these blocks are made, and concrete kerbs. Messrs. Tarmac are prepared to supply these blocks, which are standardised in size—18¾ in. by 9 in.

by 4⅜ in.—or to contract for the erection of any type of building. "Vinculum" blocks are made of slag and Portland cement under a special process at the firm's works, and weigh about 40 lb. each. The cavity wall system is adopted, and the blocks are made with holes running perpendicularly through them. The blocks are laid so that the core holes coincide in each course, and therefore run continuously through the entire height of the structure. If it is necessary that the wall should be reinforced, steel rods are introduced into these holes and grouted in with cement. Horizontal reinforcement is also used at intervals by means of steel wires; these are connected to the perpendicular rods, and a complete reinforcement throughout the entire structure is thus obtained. As a precaution against the percolation of dampness, the cavity between the inner and outer walls is filled with a liquid bitumastic composition, which sets hard. Cottages on this system are to be erected in connection with the Government housing scheme at Birmingham, Wolverhampton, Dudley and Wednesfield, and plans and estimates have been approved by the Housing Commissioners for the respective districts.

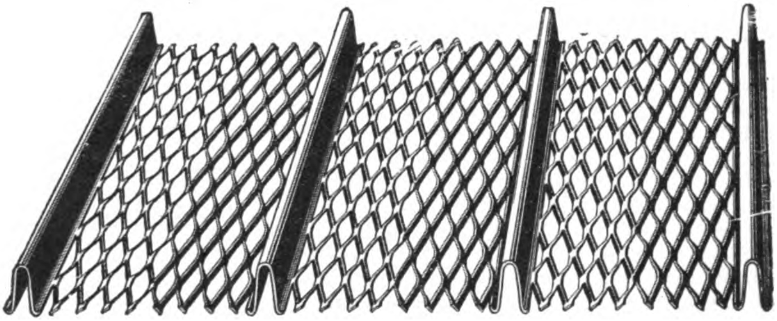
*The Lightning Construction Co., Ltd.*, exhibited Johnston's patent system of reinforced concrete cottage construction. By this system very large units are used, and these are lifted into position by a travelling crane. The slabs used for walling are equal in size to 225 ordinary bricks; floors are moulded and fixed in one piece, and staircases, consisting of fifteen steps and weighing about 4 cwt., are also cast in one piece. All the beams, columns and slabs are made with joints, and are easily grouted together. The only timber used is for the door and window frames. No scaffolding is required, and it is claimed that with the aid of a travelling crane twelve men can erect four cottages in seven days. The prices quoted for this type of construction are as follows:—six-room cottage, £450; eight-room cottage, £650; ten-room detached house, £1,000.

The "Self-Sentering" and "Trussit" reinforcements, which obviate the necessity for using shuttering in the construction of floors and walls, were shown by *The Self-Sentering Expanded Metal Works, Ltd.* These products are made of expanded metal. "Self-Sentering" is specially designed for concrete floor reinforcement, and stiffening ribs are incorporated in the process of manufacture. It can be used either flat or curved, and is made in three different weights, 29 in. wide and from 4 to 12 ft. long. "Trussit" is a corrugated expanded steel reinforcement uniformly expanded in both directions. It is claimed that "Trussit" becomes an integral part of the wall in



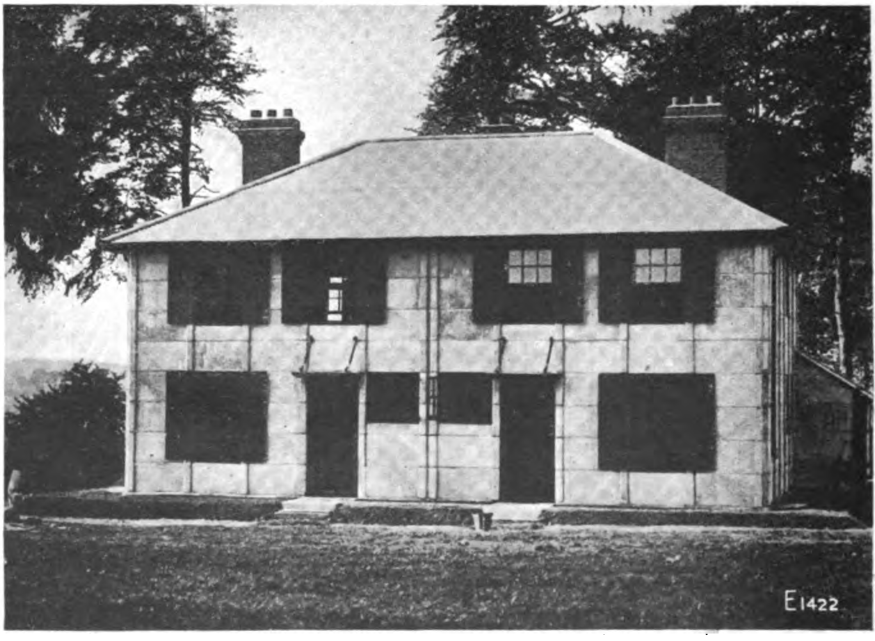
"Trussit" for Concrete Walls.

which it is used, and overcomes any tendency towards cracking which might occur through expansion or contraction of the wall due to temperature changes. It is made in three weights, in sheets 19 in. wide and from 8 to 12 ft. long. With supports at 10 ft. centres, "Trussit," with a 2 in. cement plaster, will furnish walls up to 12 ft. in height and over. The "Herringbone" metal lath for plaster ceilings was also shown. This lathing has flat ribs at 1½ in. centres and connecting ribs at ⅜ in. centres, and is much stronger than wood laths of a similar weight.



"Self-Sentering" for Concrete Floors.

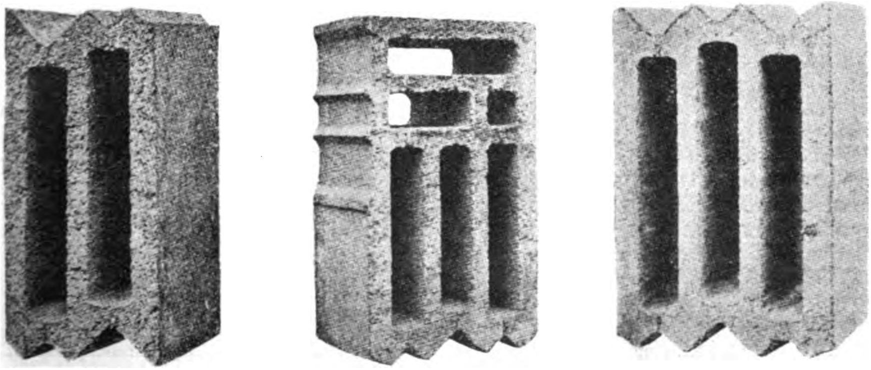
An interesting exhibit was that of *Mr. C. P. Lovell*, of Messrs. S. J. Lovell & Son, Paddington, who demonstrated a system of construction with a combination of brickwork and concrete slabs. The bricks are the same size as Flettons, and are made with slots at the ends and sides of the width of the concrete slabs and joinery in use, in this case 1½ in. The bricks are used for the construction of piers at the corners and at either side of the door and window openings, the result being a series



Cottages erected at Harefield, Middlesex.
Lovell's System of Cottage Construction.

of brickwork pillars around the building under erection. The brickwork is erected first, and as these pillars rise to a sufficient height the concrete slabs are fitted into the grooves in the bricks and cemented. The size of the slabs, doors, and window frames is standardised, and if any variation in the size of the wall is required the difference is effected by increasing or decreasing the width of the brickwork. Besides being a speedy method of erection, variations in the design of elevations can be obtained with the combination of brick and concrete which could not be obtained with the use of concrete alone, although, as in the pair of cottages we illustrate, the bricks can be cemented over and the "concrete" effect retained. This pair of cottages was erected at Harefield, Middlesex, in 28 days, Mr. Lovell's patent bricks and "Hurcan" asbestos-faced blocks and "Poilite" corrugated asbestos sheeting (manufactured by Messrs. Bell's United Asbestos Co., Ltd.) being used in their construction.

*The British Léan Co., Ltd.*, exhibited samples of concrete blocks made with the firm's special machine for use in connection with the "Léan" system of construction. These blocks are made with two or three longitudinal cavities, and the ends of the blocks are moulded with the same number of grooves, so that walls constructed on the "Léan" system have air spaces throughout their height both in the blocks themselves and at the joints. The blocks are 8 in. in thickness, and with the spaces in the middle of the block and the grooves at the ends the joints do not extend through the entire thickness of the wall, but consist of three or four distinct joints with air spaces between. It is claimed that 8 in. "Léan" walls possess damp-resisting qualities equal to a 19 in. brick wall. The blocks are made by hand with a mix of 1 part cement and 4 parts sand. The machine weighs 600–800 lb., and it is estimated that three men can produce sufficient blocks for the erection of 300–400 sq. ft. of walling per day. The firm is desirous of letting the machines on hire on a royalty basis.



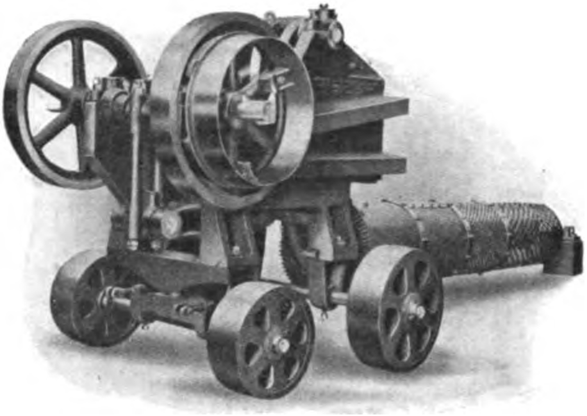
THE LÉAN CONCRETE BRICK.

### A NEW PUMP.

*Messrs. Boulton & Paul, Ltd.*, exhibited a new method of elevating water, viz., the "Chaine Helice" liquid elevator. This apparatus pumps water without the use of pipes, valves or buckets. It consists of an endless chain surrounded by coils of wire which move with the chain, being fixed to the latter at frequent intervals. The spiral chain is suspended from a grooved pulley, by means of which motion may be imparted to the chain, and the lower end dips about 2 ft. into the well. When rotary motion is imparted to the grooved pulley the suspended spiral chain ascends filled with water on one side, the water being held in the chain by capillary attraction, and as there is a continuous spiral of such drops a sort of skin is produced, which holds the tube of water together. Owing to the fact that the core of the spiral is a link chain, and that friction is purposely introduced in other ways, and as the chain is being pulled up faster than the liquid can run back, the result is a continual rise of water. As the spiral passes over the grooved pulley at the top it opens out slightly, and centrifugal force causes the water to be thrown off. It is caught in a simple tank, and cannot run back through the hole by means of which the chain entered the tank, owing to this hole being surrounded by a sleeve. The quantities lifted vary with the size of the chain, the largest chain used at the present time delivering 2,500 gallons per hour. The greatest depth from which water is being lifted at present is 300 ft.

### CONCRETE MACHINERY.

*Messrs. H. R. Marsden, Ltd.*, are well known as makers of all kinds of stone breakers, ore crushers, and screening and elevating plant, and their exhibit consisted of a Blake Marsden " X " type lever-hammer motion stone breaker. This model embodies several improvements over the older types, including a new adjustable gudgeon bearing and an improved locking device for the toggle block. The working parts are easily accessible, and the main bearings, which are automatically lubricated, have been removed as far as possible from exposure to grit and dust. The machine illustrated is fitted with a portable screen, and is made with mouths from 8 in. by 6 in. to 30 in. by 18 in., with an approximate output of stone crushed to road-metal size and under of 2½ tons and 21 tons per hour respectively.



THE BLAKE-MARSDEN STONE CRUSHER.

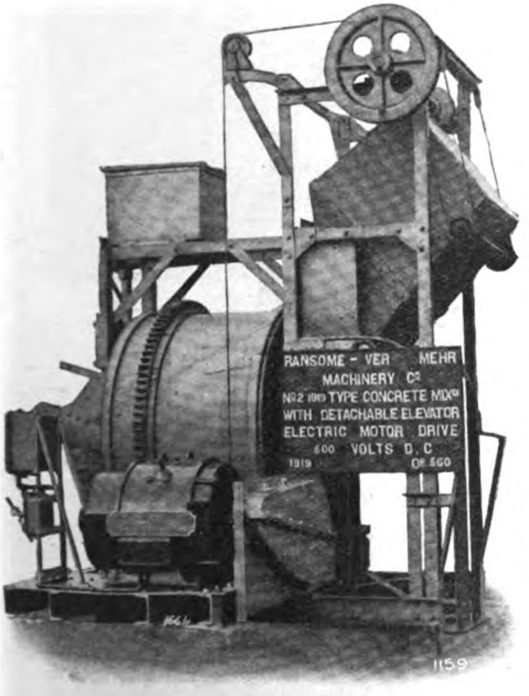
*Messrs Muirhead, McDonald, Wilson & Co., Ltd.*, showed a special steam shovel known as the " Erie " shovel, specially useful for road excavation. We referred to this shovel in our November issue, p. 657, and the accompanying illustration shows the shovel in operation. The " Erie " is so designed that the bucket in taking a stroke

THE " ERIE " ROAD SHOVEL.

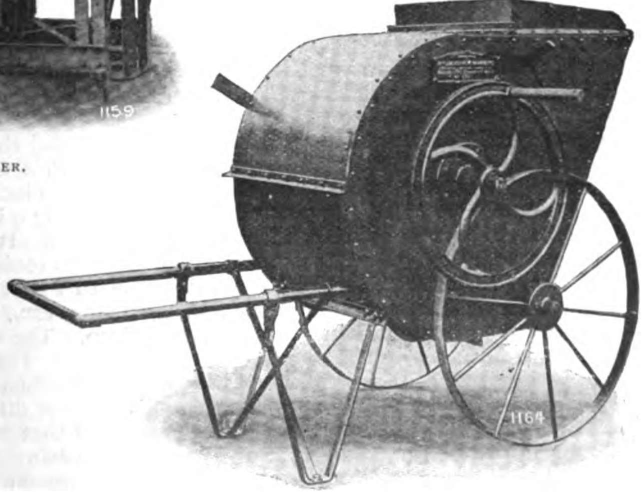
travels horizontally forward in a straight line for a distance of 8 ft. 6 in. before this motion becomes radial; thus the bucket can fill itself to its full capacity on a shallow cut. Some of the points to be noted in connection with these shovels is that there are only three levers to govern the digging motions—in contrast with 5, 6 or 7 levers ordinarily used. Another advantage is that on highway work the shovel instantly removes large boulders which are partly above ground and partly below. No stoppage is needed to make any special adjustments. 500 or 600 cu. yds. per day, or more, can be taken out in ordinary bank work. In very shallow cuts through hard material, such as old macadam or telford, 300 to 400 cubic yards per day, or more, can be removed.

The "Erie" can also be used for ordinary excavation work and was recently successfully used in the excavation for the foundations of a small factory in Hackney.

*The Ransome-verMehr Machinery Co., Ltd.*, showed two concrete mixers, a concrete carrying cart, a tipping wagon, samples of steel sheet piling and a pile helmet for pitching reinforced concrete piles and protecting same during driving. The "No. 0" mixer is mounted on wheels and fitted with a detachable elevator and a petrol unit extension. The "No. 2," which we illustrate, is a stationary electrically driven machine, also with a detachable elevator. These mixers are made in various sizes, with batch capacities of from 3 to 80 cu. ft., and with approximate outputs of from 22 to 1,320 cu. yd. per day. The "Ransome" hoist, which delivers a batch of concrete to a height of 100 ft. every two minutes, was also shown, and a small hand mixer. This mixer is essentially a "one-man" machine, and has a capacity of about one barrow-load—*i.e.*, 2 cu. ft. The output is approximately from 2 to 2½ cu. yd. per hour, and it is fitted with a measuring hopper. A hand-barrow for carrying concrete, exhibited on the same stand, is so designed and mounted on large wheels that, however the mix is thrown in, the centre of gravity remains under the axle, thus ensuring a perfect balance and consequent ease in handling.

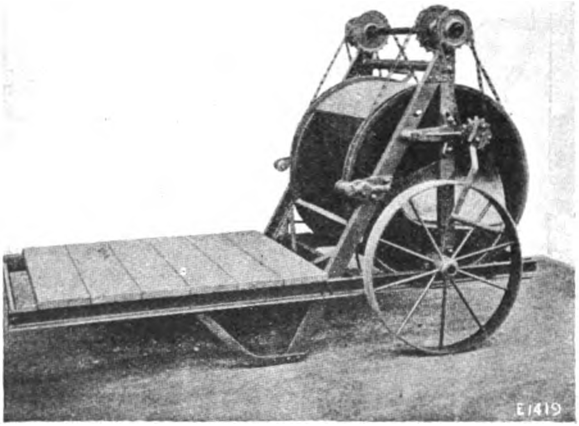


RANSOME CONCRETE MIXER.



RANSOME HAND MIXER.

*Messrs. Stothert & Pitt, Ltd.*, and *T. L. Smith & Co.* exhibited three types of concrete mixers, two of which, the "Smith" power mixer and the "Smith" hand mixer, are constructed for mixing either concrete or tar-macadam. The power machine is capable of dealing with 13 cu. ft. of mixed material per batch, and is fitted with fast and loose pulleys for belt drive. The "Smith" hand mixer, which we illustrate, appears to be a very efficient machine for mixing small batches, its capacity being 3 cu. ft. of mixed material per batch, or slightly more if the material is unmixed. It is operated by two men by means of handles at either side, and it is claimed that between 20 and 30 batches per hour can be turned out. The cylinder is of the drum type, and suspended on chains. The ends of the cylinder slope inwards until they nearly meet, forming two wedge-shaped chambers united by a 4½-in. slot extending diametrically across the drum. The batch is fed into the drum from the platform, and when the drum is revolved the material is poured from chamber to chamber, the compression of the mass in the V-shaped space above the slot producing the mix The action is practically that of an ordinary sand-glass, and two revolutions are sufficient to produce a thorough mix. The machine is fitted with a separate opening for cleaning purposes. Messrs. Stothert & Pitt's standard power mixer has a capacity of 13 cu. ft. per batch, and is a very compact machine. The "Dricrete" block-making machine, manufactured by the same firm, is designed for placing a thin face of waterproofed cement on to a porous concrete block. It is recommended that the body of the block be made of a 6 to 1 aggregate, and the facing of 3 parts of clean, sharp sand and 1 part Portland cement, mixed with a waterproofing material. The facing is ½ in. thick, and is applied to the top of the block while it is in the machine. The standard machine makes blocks 18 in. by 9 in. by 9 in., and partition slabs, with or without a waterproof face, can also be turned out. It is stated that two men can produce 200 blocks in ten hours. This machine was recently illustrated in our pages.

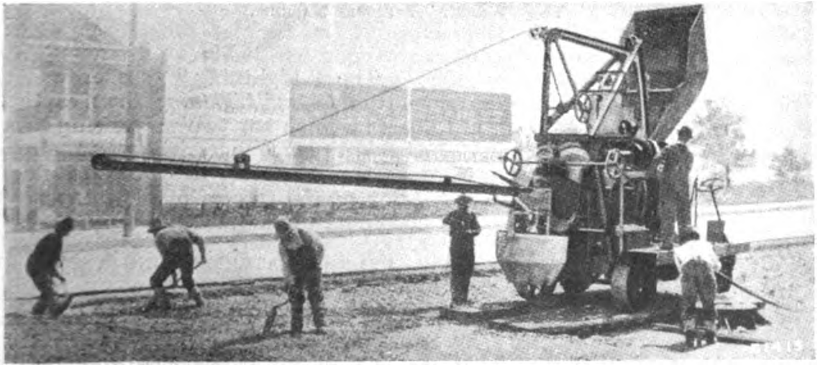


THE "SMITH' HAND MIXER.

The "Kirk" block-making machine, shown by *Messrs. R. H. Kirk & Co.*, produces concrete blocks, sills, partition slabs, coping, etc., of any length from 3 in. to 5 ft., up to 13 in. in width and up to 6⅝ in. deep. The moulding box is cast in one piece, and adjusted to the required size with liners. The blocks are cast face down, thus ensuring the angles being clearly delineated when making rock-faced blocks. The face plates are of aluminium. Several blocks of different sizes can be made in one operation with this machine, and it is claimed that two men can make sills 5 ft. by 10½ in. by 6⅝ in. at the rate of five minutes each. After the blocks have been tamped, the moulding box is turned completely over on to a platform, by means of a hand wheel, for the removal of the blocks.

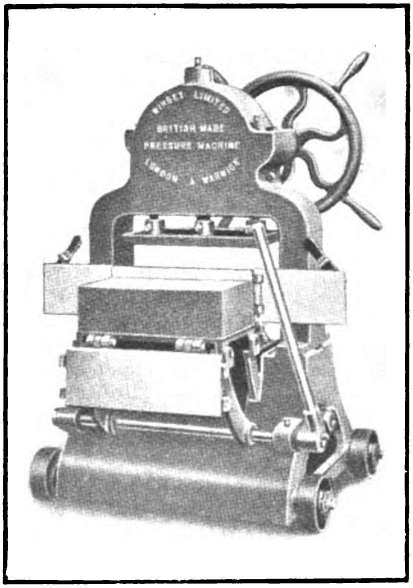
"P. & H." Trench Tamper.

*Messrs. Gaston, Ltd.*, are the sole importers in this country of the "Rex" mixer and paver, manufactured by the Chain Belt Co., U.S.A. The "Rex 10 E" paver is an 8 h.p. machine with a capacity of 14 cu. ft. of unmixed materials, or 10 cu. ft. of mixed, per batch, and an output of 800 sq. yd. of 6-in. concrete per 10-hour day is claimed. It is fitted with a power loader to hold 16 cu. ft., and a 20 ft. long distributing shaft and bucket. The boom can be swung at an angle of 180°, and the bucket has a speed of about 200 ft. per minute. This mixer is also made with a distributing spout, 11 ft. long, with three discharge points. Messrs. Gaston are also the sole importers of the "P. & H." power trench-tamping machine. This machine is fitted with a 3 h.p. gasolene engine, and has a tamping capacity of 18 sq. ft. per minute. The weight of the ram is 150 lb., with a stroke of 26 in. Trenches of any depth can be tamped by this machine, according to the length of the ram used, and the tamping head is supplied in various sizes.



The "Rex" Mixer and Paver.

*Messrs. Winget, Ltd.*, gave demonstrations of concrete block making with the well-known "Winget" machine, and also showed the "Winget" pressure machine, a concrete mixer, a stone breaker and crusher, and a machine for making roofing tiles. It is claimed that with the standard machine sufficient blocks can be made for a two-storey cottage with an area of 400 sq. ft. in three and a half days. A feature of the pressure machine is that, in addition to blocks and slabs, half-blocks can be made. It is estimated that two men can mix their own material by hand and make 60 blocks per hour. After the moulding box has been filled and roughly screeded off, it is brought beneath the ram-plate with a single motion of the lever, and pressure is then applied by the hand wheel at the back of the machine. The wheel is rotated in the same direction until the ram regains its original position, and the moulding box is brought forward for the removal of the block by a reverse motion of the lever. The machine is mounted on wheels, and has a total weight of 8 cwt. "Winget" machines were extensively used in the construction of housing schemes for munition workers during the war, and of these the Chepstow and Crayford garden cities are excellent examples.

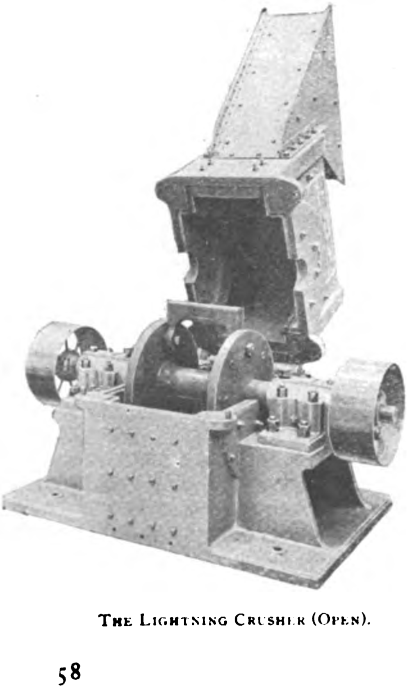


THE "WINGET" PRESSURE MACHINE.

The "Lightning" crusher was shown by the *Patent Lightning Crusher Co., Ltd*, This machine has two pulverising hammers. and will reduce material to ¾ in. size at the rate of 10 tons per hour, or to a finer condition at the rate of 6 to 3 tons per hour, according to the material.

### CEMENT WATERPROOFING AND PAINT.

The stand of *Messrs. Kerner-Greenwood & Co., Ltd.*, contained many interesting examples of the applications of "Pudlo," a powder for waterproofing cement. There were on view a full-sized section of solid concrete floor with a 1 in. layer of "Pudloed" cement topping; a length of stoneware drain jointed with three parts sand and one part Portland cement and "Pudlo"; and a water tank constructed of thin porous blocks with a ¼ in. facing of "Pudloed" cement. The concrete block was immersed in water up to the topping, and the drain and tank were filled with water, but although some of the porous concrete was partially saturated with water, the faces were



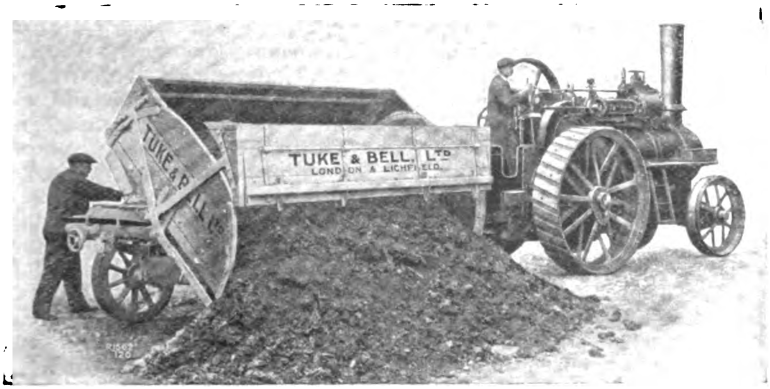
THE LIGHTNING CRUSHER (OPEN).

perfectly dry. It is claimed that " Pudlo " renders concrete permanently waterproof, and becomes more resistant to damp with age. For various classes of work from floor screeding (as a preventative of rising dampness) to concrete roofing, Messrs. Kerner-Greenwood recommend the addition of from 2 to 5 lb. of " Pudlo " to 100 lb. of cement, and the cost of the waterproofing material for such work varies from 6d. per yard super for walls, to 1s. 9d. per yard super for concrete roofs.

*Messrs. Super-Cement, Ltd.*, showed many vessels made of Super-Cement and sand, and filled with water, and also trays made of breeze concrete, the insides of which had been lightly brushed over with a slurry of Super-Cement. These vessels all appeared to be perfectly watertight, and in spite of the very slight application of Super-Cement the porous aggregates showed no signs of the penetration of water. It is claimed that, size for size, the particles of this special cement are more capable of combining with water than the particles of ordinary cement, and therefore that mortars made of Super-Cement are stronger than those made of ordinary cement more finely powdered. Super-Cement is produced from Portland cement clinker by grinding in with it specially treated gypsum, which is claimed to be more soluble than untreated gypsum, and as more of it is dissolved with the addition of water, more of the clinker particles are brought into combination with the water. When Super-Cement concrete is graded so as to reduce the percentage of voids to a minimum, and mixed with sufficient cement to cover every grain and fill all the interstices, it is claimed that it will resist the penetration of water up to a pressure of 330 lb. per sq. in.

*Messrs. Dixon's White, Ltd.*, showed samples of concrete rendered with " Rogg " concrete paint. This paint is made in all colours and tints, and gives a glossy finish resembling enamel. " Rogg " paint is supplied ready for use, and does not require thinning out, and it is stated that one gallon will cover from 70 to 80 sq. yd. with one coat.

Among the large number of exhibits of motor lorries and tipping wagons, that of *Messrs. Tuke & Bell, Ltd.*, who showed their "Constable" patent tipping wagon and a sleeping van, may be mentioned. The side-tipping wagon is operated by a screw, which traverses the body on anti-friction rollers. When the body has travelled to a point where body and load balance, toggles come into operation to control the tipping, which is by gravity—the man lifting no part of the load. An angle of 50° is attained, which is sufficient to eject any class of material. The door on the side of the body, being released, automatically unfastens, and remains in its normal position and out of the way of the material being tipped. The discharging of the load is effected in 90 seconds.



THE CONSTABLE TIPPING WAGON.

# PRACTICAL NOTES ON PROBLEMS IN CONCRETE CONSTRUCTION

*Under this heading we propose to publish information which should be of special value to contractors, supervisors, clerks of works, etc., dealing with the actual execution of concrete work. This information, wherever possible, will be based on practical experience and will deal with all aspects of concrete work.—ED.*

## WHEN TO STRIKE MOULDS.

To the clerk of works it is a matter of concern to see that the moulds in a reinforced concrete building or structure are not struck prematurely. It is safe to say that a very high percentage of the failures which have taken place with concrete have been traceable to too rapid removal of form-work.

On the other hand, it is often important that the forms are not left up unnecessarily long, because in a building of many floors, clearly, it makes a very material difference to the cost if the centering for first floor slabs can be removed in time to be re-used for second, third and upper floors without delaying construction, or whether it has to be left up while second-floor centering is constructed with a fresh supply of timber. As a rough approximation, the centering represents one third the cost of an average concrete structure, and the use and waste of timber is generally about one third of the cost of centering—when it is used about four times—the remaining two thirds being labour.

Obviously, then, if it should be necessary, as in the example just mentioned, to provide twice as much timber, and only use it twice, the increased cost of the building will be about one ninth, or about 11 per cent. It may be argued that this extra timber will represent so much more useful timber to remove from the job on completion, and that this will be valuable. This has, however, been allowed for in the above calculation, as only use and waste have been charged. As a matter of fact, we have to remember that there is an additional cost with the more timber in the extra labour to prepare this for the centering, which generally costs more to construct from new timber than to re-erect from the floor below, particularly where the arrangement of beams and columns follows up with little variation from floor to floor, as is usual.

When, however, the centering is removed from the building, it will probably not fit a new structure to which it may later be taken, and to cut it to fit an entirely different job, in which the beams are probably of different lengths and sizes, the slabs all different lengths, etc., generally means so much additional extra labour cost as compared with the cost of new timber that it is often doubtful whether it is worth while. The reason for this is that when the boards have been used for centering, they are saturated with cement, which blunts the carpenter's tools so rapidly that they get through far less useful work in a given time. This applies particularly when the boards have been away from the job some time and the cement on them hardened. When they are re-used immediately they are struck the effect still exists, but is greatly minimised as the cement then rubs off easily, and is quite soft comparatively.

The proper procedure, where it can be done, is to arrange that boards are struck as they are required for re-use. This also prevents a lot of pilfering from the job as compared with the arrangement under which a lot of unused timber may be found lying on the site. As the boards are struck they should be immediately cleaned down by a squad of labourers with water and a wire brush and a scraping tool, and then handed over to the carpenter to re-erect in corresponding positions to those they occupied on the lower floors.

Contractors will agree that returned centering, owing to the causes above mentioned, has only a small fraction of the value of new boards, say, one quarter at the most.

The time of removal of the centering affects other things besides cost. It also has a material effect on the time of completion of buildings. Consider, for example, a building of six floors, and let us compare the procedure in the two cases in which the centering may be removed in (*a*) two weeks; (*b*) six weeks. We will also assume that each floor occupies, say, four weeks to construct, including centering, steel-fixing, and concreting.

Suppose now we finish first floor on a certain date and consider case (*a*). In two weeks we can remove our centering and re-erect it ready for second floor to be constructed a further two weeks later, by which time first floor is strong enough to carry second floor as well as itself. Therefore, not only is but one lot of centering needed, but only one set of props, and the space under all floors is left free for finishings (plaster, etc.) a fortnight after the floor above was concreted.

Compare this now with case (*b*). Here a second lot of centering has to be provided for second floor as first floor centering cannot be removed in time. Also, as first floor is not strong enough to carry second till it is, say, eight weeks old, the struts from ground to first have to be left in the eight weeks. But by this time third floor also has been concreted and adds its weight to struts from ground to first, which therefore have to be left in, say, ten weeks, and also have to be somewhat stouter. With this arrangement, probably three complete sets of struts would be needed, which would prevent the finishings proceeding under a particular floor until some ten weeks after it was concreted, and obviously, therefore, delays completion of the building by eight weeks as compared by case (*a*).

Enough has now been said to show how very important it is that people in charge of concrete buildings should have a very clear idea of the principles governing the time that centering should be left up, and these principles may now be explained.

(*To be continued next month.*)

## MEMORANDA.

**Patching a Ship with Concrete.**—In a recent number of the *Illustrated London News* a short description was given, with illustrations, of the salvage of a steamer which was sunk by a German torpedo. The Admiralty Salvage Section decided to attempt to save her by patching the hole in the hull with reinforced concrete. Under the expert supervision of the salvage officer, the divers, after great trouble, managed to build up wooden moulds, which, when they had been duly inspected and passed by the salvage engineer, were filled with concrete mixed in certain special proportions. The plan proved a great success. The concrete set as hard as rock, and the ship was pumped out and raised.

**Self-Sinking Concrete Piles.**—In rebuilding a bridge across the Platte river in the United States, Mr. E. Bignell-Jones used pre-moulded self-sinking concrete piles. These piles have in their centre a double conduit, formed by two pipes of 2 in. and 4 in. diameter, one within the other, the inner pipe feeding a water jet at the pile nose intended to excavate or scour away material as the pile enters, the outer annular space between the pipe skins conveying water to side jets along the length of the pile, with nozzles pointing upwards, for the purpose of easing entrance and for the removal of excavated material. The inside pipe takes water at from 200 lb. to 300 lb. pressure, and the outer, feeding the lateral pipes, is supplied with water at 150 lb., the volume being at the rate of 700 gals. per minute. When pumping stops, the material around the pile settles in and grips effectively. Piles 50 ft. long and 16 in. sq., in sand and clay, have sustained successfully loads of 50 tons. Owing to the side jet lubrication, a pile during sinking can, on meeting serious obstruction, be lifted, and again dropped to break through the obstacle, or may be withdrawn and a shorter length used. The same principle has been applied to sheet piling.—From *The Technical Review*.

**The Inspection of Engineering Material.**—At a meeting of the Technical Inspection Association, two papers were read by Mr. W. D. Summerfield and Mr. H. J. Davey on the necessity of inspecting engineering material. The first-named paper dealt with the following points: (1) The necessity for inspection; (2) the advantage to the buyer; (3) the benefit to the contractor; (4) abuses of inspection; and (5) the inspector. Mr. Davey, in his paper, took up the question of specifications and their bearing on inspection. Dealing with the question of concrete, he emphasised the necessity of inspecting and testing the materials intended for concrete if good results are to be obtained.

# METAFORMS.

(*Contributed.*)

It is now quite universally agreed that concrete as a building medium for all types of structures is rapidly taking preference over all other constructional materials. Two of the chief reasons for this being that there are unlimited quantities of the necessary raw materials or ingredients on hand in almost every locality, and that the mixing can be done rapidly and efficiently by semi-skilled labour "in situ" with one or other of the numerous machines for this purpose now on the market. The comparatively slow rate of progress in concrete construction in the past has been due to the widespread use of wood-forms for the erection of all types of concrete structures. Always a costly method in pre-war days, current statistics show that from 33⅓ per cent. to 45 per cent. of the total cost of every concrete building is absorbed by the timber shuttering and the skilled labour required to erect and dismantle it. Further, of the timber employed, at least 25 per cent. is rendered useless for further constructional work, and before the remainder can be used again skilled carpentry labour has to cut and fit it to the new form.

An interesting method which claims to overcome the use of timber shuttering is the recent introduction into this country of a system of very simply constructed and easily handled steel shuttering, known under the trade name of "Metaforms," which has already been adopted by several well-known contractors who are actually engaged at the present time on the erection of concrete structures with this system in the London district and also in the north.

These standardised metal shutters are interchangeable and adjustable to the varying specifications of concrete walls by means of the range of nested sizes and the individual sheets of metal are quickly and rigidly interlocked to make one smooth continuous form. They consist of sheets of 16-gauge sheet iron with a 1 in. by 1 in. mild steel angle iron around the edges and braced across the centre, and two small iron clamps riveted to the right-hand vertical angle of each plate which, by a single upward push on each of the two clamps, locks each mould firmly to its neighbour. A reverse movement unlocks them. "Metaforms" are built on a standard depth of 24 in. throughout, and by a comprehensive nest of sizes ranging from 24 in. in width down to 2 in. wide, decreasing by 2 in., with two odd sizes at 5 in. and 3 in.; there are three styles of corner connections—viz., inside and outside right angle connections, and the hinged corner connections with which obtuse angles of any desired degree can be obtained on both the inside and outside wall. The construction of both the moulds and corner connections is shown in detail in *Figs.* 1 and 2, and illustrations of typical set-ups showing their use and application will also be found in *Fig.* 3.

Not more than three courses of moulds—*i.e.*, sufficient to go three times round the perimeter of the building, are required to do continuous pouring to any desired height. The accompanying illustration demonstrates this point, where three courses of moulds will be seen in position above the 6 ft. height of finished wall (*Fig.* 4). As soon as the top or third course of moulds has been poured, the bottom or first course will be unclamped and placed on top of the third course, thus becoming the fourth course, and so on with the other courses as fast as the concrete sets, the speed of the latter operation being largely governed by the wetness of the concrete and the climatic conditions prevailing at the time. A claim made for "Metaforms" is that it is possible to start pouring the walls within two hours of commencing the erection of the moulds. In ordinary dry weather, and using good concrete, the first and second courses of forms can be taken off next day and rebuilt on top of the last course, which is left in place each time to act as a support and gauge for the next course. It is stated that no spreading of the wall is possible, as each plate is securely wired to the one facing it and windlassed to draw the two moulds tightly together, thus effectually preventing any tendency on the part of the moulds to bulge. These wires are easily nipped with a pair of shears when the plates are ready to be removed from the wall surface. Alignment of adjacent plates is automatically governed by stout dowel

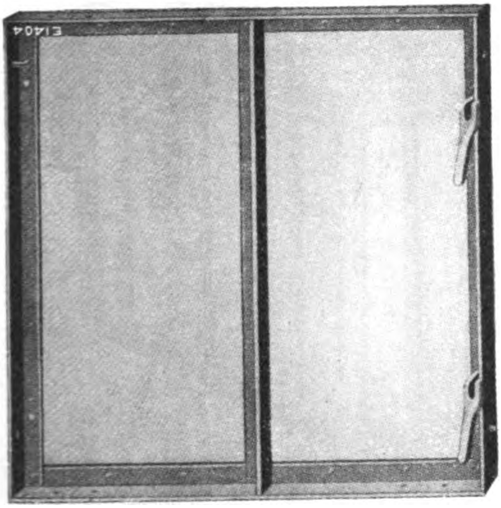
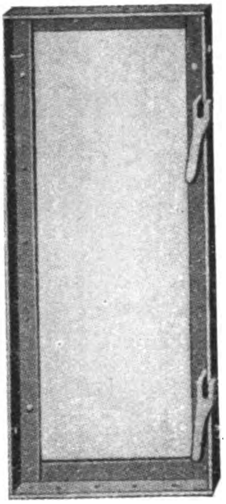


FIG. 1. STANDARD UNIT.



FRACTIONAL UNIT.

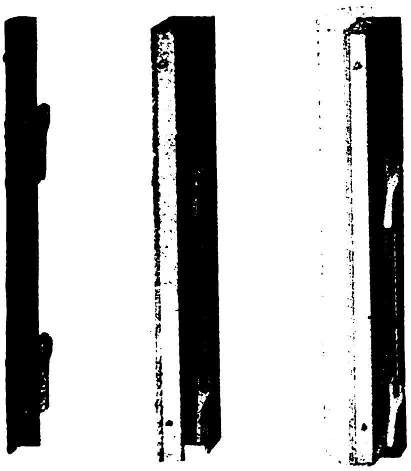
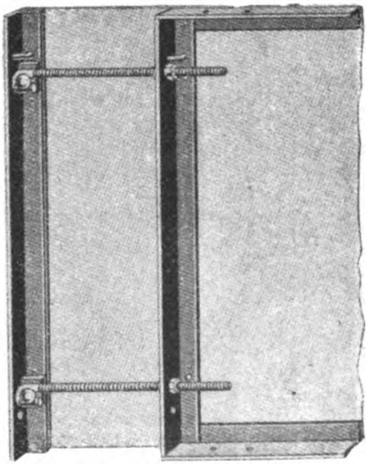


FIG. 2. OUTSIDE AND INSIDE CORNERS AND HINGED SECTIONS.



ADJUSTABLE UNIT.

pins, which protrude from the right-hand vertical angle iron of each mould and catch into holes provided for them in the left-hand vertical angle on the next mould. Stay-rods with irregularly spaced notches in them drop into holes provided for them on the top angle iron of the inner and outer moulds, thus assuring proper spacing between moulds and giving a range of wall thicknesses from 6 in. to 14 in., advancing by ½ in.

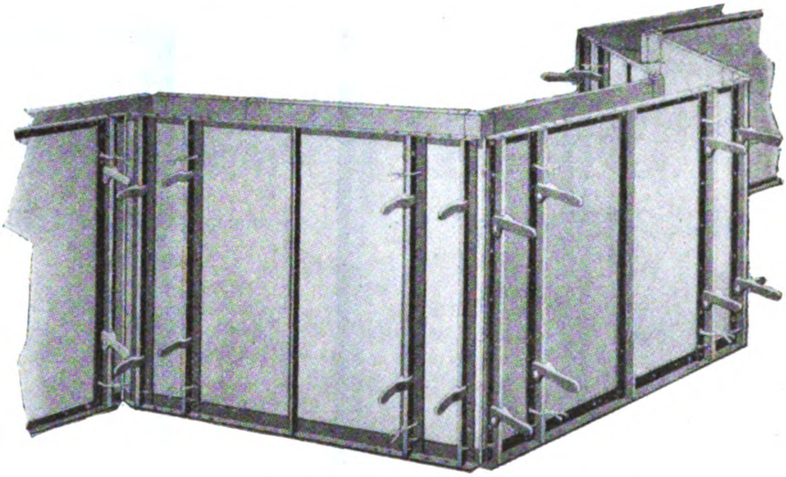


FIG. 3. COMBINATION OF ANGLE CONSTRUCTION WITH HINGED UNITS.

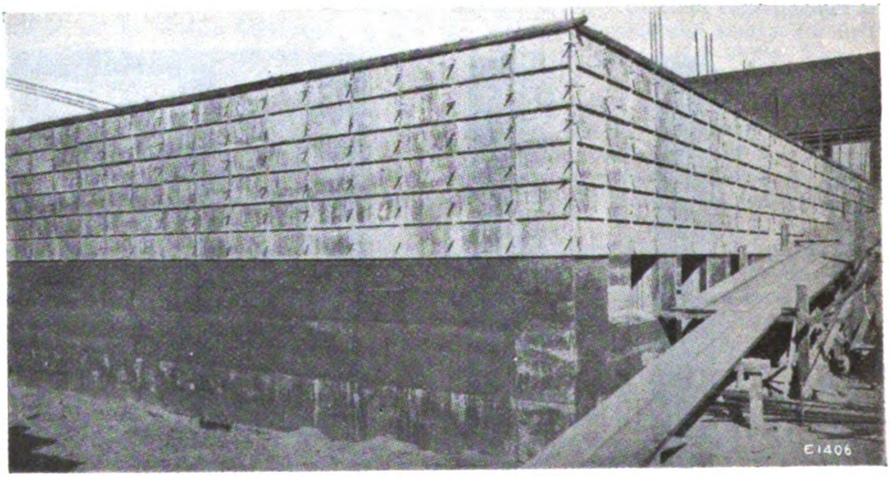


FIG. 4. A WALL IN COURSE OF CONSTRUCTION.

The thorough standardisation of parts not only permits their duplication at any time, but makes the system very flexible by reason of their easy interchangeability. Further, the requisite number and sizes of moulds, connections and stay-rods to cast any particular structure may be indicated in advance right on the working drawings and despatched to the site ready for erection, so that only the exact quantity of units required are on the site, thus effecting a great saving both in time and cartage.

The question of doors and windows presents no difficulty whatsoever, as the frames are dropped into the moulds at the proper places and the wall cast around them, the forms continuing right across the opening as shown in the illustration (*Fig.* 5).

*Circular Buildings.*—Curved flexible 16-gauge sheet steel plates are also supplied to accommodate any diameter of circular building, such as silos, chimney stacks, etc. These are precisely similar in sizes to the forms for straight wall work, but they differ somewhat in construction, only being stiffened vertically by a 1 in. by 1 in. angle iron riveted along the two vertical edges, and the horizontal strengthening is obtained by a 1 in. band of spring steel in place of the angle iron, thus preserving the flexibility of the plates for accommodation to varying diameters. Two sets of these plates, one concave and the other convex, compose the inner and outer shells of the form. Another feature of the circular moulds is the hooked clamp located in the centre of the top edge of plate, which catches a raised rivet on the bottom edge of the plate immediately above, drawing the two moulds firmly together and giving a smooth cement proof joint.

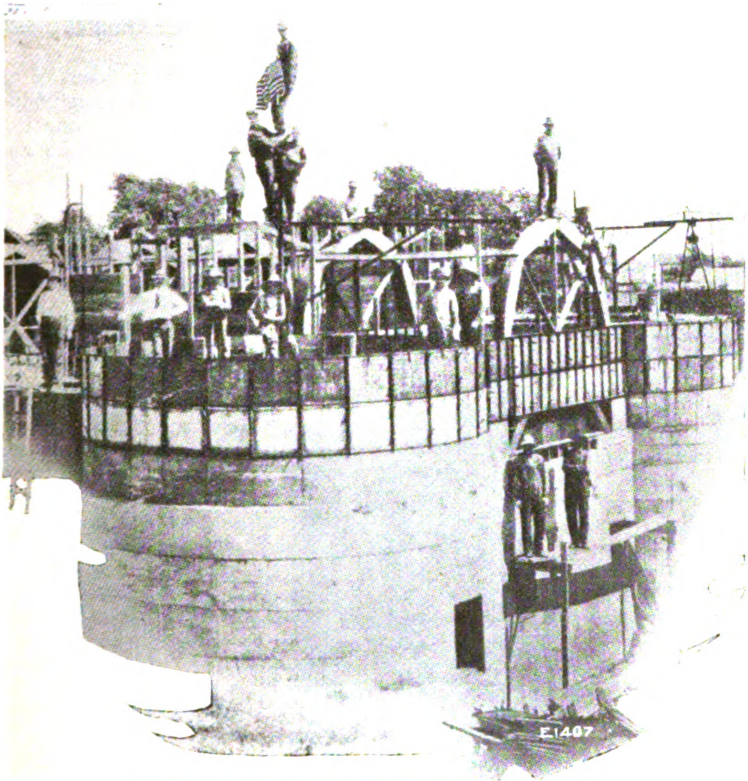


FIG. 5. COMBINATION OF STRAIGHT AND CIRCULAR MOULDS.

The inner or concave plates are erected round a centre mast, which is capable of being adjusted to required heights by additional lengths of the $2\frac{1}{2}$ in. extra heavy pipe, and to this are locked, by means of centre collars, two sets of angle-iron scaffold arms adjustable in length for varying diameters and radiating from the mast to the inner shell, thus forming what is termed a "spider," which rests on an angle-iron ring in sections locked together by means of clamps and supported by clips or ring rests riveted to each inside plate, as shown in the illustration. These arms hold the inner shell plate out to the correct internal diameter, whilst the outer shell is effectually held concentrically to the other at the proper distance by stay-rods consisting of short lengths of slotted T-iron, which are slipped on the top of the inner and outer shells. A light steel derrick, strongly braced and supported by the centre mast and outer legs, hoists the concrete into the carrier or distributing bucket, which runs on a track of wide band iron in adjustable sections mounted on the top ring of the outfit. The small carriage frame for distributing bucket is also capable of being adjusted to varying diameters and is pivoted to the centre mast by a split collar, whilst the outer end is supported on the track by two flanged wheels. Any form of silo, chimney stack or other circular building may be erected to any height desired with one set of three courses of "Metaforms" and the usual accessories.

Silo construction calls for very few additions to the standard circular outfit already described, differing in only two important particulars—the chute and the continuous door. A round chute is provided for and the units are similar to the standard unit plates. The special items consist of two specially designed units which fit into the shell at the intersection of the chute forms: Their construction provides for the slot which holds the planks forming the continuous door. *Fig.* 6 shows a silo some 40 ft. high and erection still proceeding, with three courses of moulds only in use.

The advantage of the use of straight wall and circular moulds combined on one building can be seen in *Fig.* 5 already referred to.

The problem of roof construction is solved by two distinct types of adjustable roof moulds. The adjustable dome roof mould consists of curved segments of steel, and includes complete cornice and dormer window mould. The cone roof mould is on the same principle, but with straight segments, also complete cornice and dormer window mould, and is self-supporting.

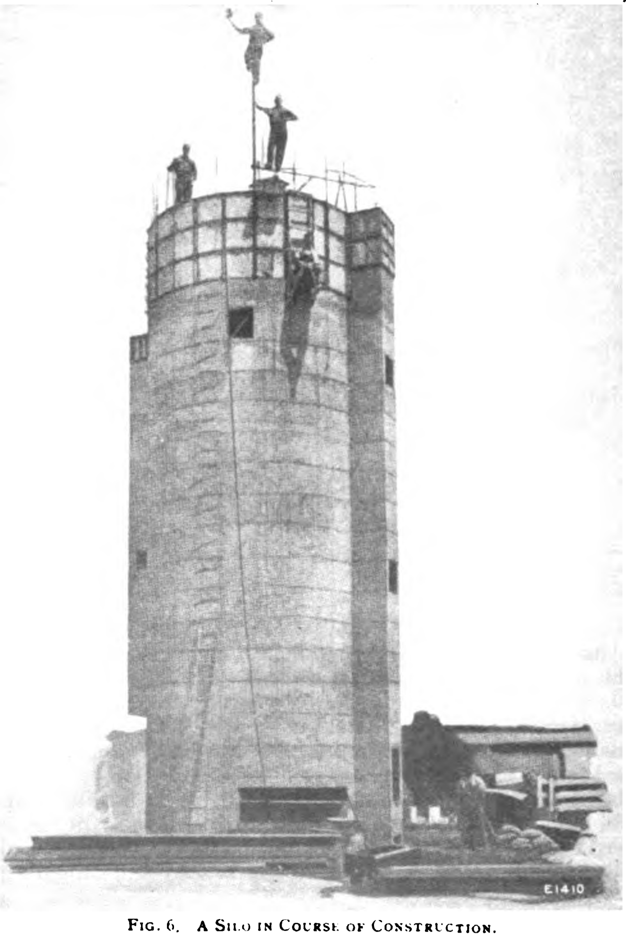


FIG. 6. A SILO IN COURSE OF CONSTRUCTION.

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

*In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.*

*Question.—A.M.B. writes to enquire :— Will you please explain why compression steel on top of a beam is sometimes used and sometimes omitted, and say when it is necessary?*

*Answer.*—Usually, compression steel is not necessary. The general governing principle of reinforcing concrete is based on the fact that concrete is weak in tension and strong in compression. The breaking values are roughly 200 lb./in.$^2$ in tension, and 2,000 lb./in.$^2$ in compression, the ratio being about ten to one.

In other words, if we reinforce a beam on the tension side, we can make it ten times as strong as it was before it was reinforced, and yet the beam will be still strong enough on the compression side.

It is only in the exceptional cases when we need to make it stronger even than this —without increasing the size—that compression reinforcement becomes necessary. Such cases mostly occur where, for some reason, the span is very great or headroom unusually limited, so that the minimum size of beam possible has to be used.

As a rule, the use of compression steel is uneconomical, and should, therefore, be confined to special cases such as those above mentioned. Its un-economy (if such a term may be used) arises from the fact that whereas the tension steel may safely be stressed to 16,000 lb./in.$^2$, the compression steel (with ordinary safe stresses of 600 lb./in.$^2$ in the concrete) cannot exceed 9,000 lb./in.$^2$ if it is right at the top edge of the beam, and is generally as low as 6,000 lb./in.$^2$ owing to the steel, for obvious practical reasons, being actually nearer the neutral axis than the top edge of the beam.

In beams in which the tension steel is fully stressed to 16,000 lb./in.$^2$, compression steel will generally begin to be necessary when the percentage of tension steel exceeds 0·675 per cent. In the case of rectangular beams (beams not monolithic with a concrete slab over) the percentage is arrived at by dividing the area of steel multiplied by a hundred by the width of the beam, and its depth from the top of the steel.

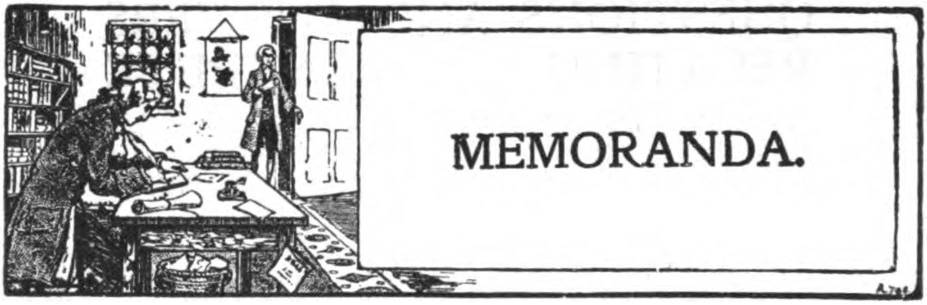
In the case of T beams (beams monolithic with a concrete slab over) the same rule applies, but the width to take into account may then be taken as the spacing from beam to beam, or one-third of the span of the beam, whichever is the lesser.

If, howevei, the thickness of the slab is less than one-ninth the depth of the beam, the above rule does not apply, and such a beam must be calculated in accordance with methods too long to describe here, and the reader is referred to textbooks, names of which will be suggested if desired.

## MEMORANDA.

**Coast Protection at Rhyl.**—The Rhyl Council recently discussed the steps to be taken to protect the coast, and in particular to prevent erosion in the harbour. The Road and Foreshore Committee recommended, and it was agreed by the Council, that 6,000 sandbags be purchased from the Government, and that these be filled with concrete for the purpose of diverting the course of the river.

**Reinforced Concrete Posts as Road Warnings.**—Acting in conjunction with the Suffolk County Automobile Club, the R.A.C. has arranged to erect posts of reinforced concrete with the object of indicating the depth of water in all the watersplashes and fords on main and rural roads in the county of East Suffolk. It is estimated that between 70 and 80 of these posts will be erected, and their practical value to motorists may be estimated from the fact that the depths of water splashes encountered on the roads of East Suffolk during the winter vary from 6 in. to 6 ft. 6 in.



*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

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## HOUSING NOTES.

**The L.C.C. and Methods of Building Construction.**—On October 28th, 1919, the London County Council referred it to the Housing of the Working Classes Committee to consider the practicability and expediency of erecting wooden cottages to relieve the housing shortage, and in its report the Committee makes some interesting comparisons between the relative costs of cottages constructed of wood, brick and concrete. The Committee is strongly opposed to wooden houses, both on the grounds of cost, durability and the speed with which they can be erected in this country. With regard to the cost, it is pointed out that the wooden bungalow approved by the Ministry of Health would cost £680 inclusive of water supply, lighting, drainage, etc., whereas brick cottages with similar accommodation erected on the Council's Old Oak Estate, Hammersmith, would cost £582 10s., and if built of concrete the cost would be even less. It is also stated that three timber-frame houses ordered from British Columbia in May, 1919, were still awaiting shipment, and inquiries as to the possibility of obtaining delivery of wooden houses from other sources had not yielded satisfactory results. The question of concrete houses was considered from the points of view of relative cost and rapidity of erection, and the Committee came to the conclusion that where the necessary materials were available on the site the building of concrete houses might materially help in the Council's housing schemes. Three methods of concrete construction were considered, viz., (i.) plain concrete; (ii.) concrete blocks; and (iii.) reinforced concrete, and the Committee was most favourably impressed with cavity wall construction with plain concrete blocks made by machinery on the building site. It is estimated that cottages can be erected more cheaply by this method than with bricks, and as bulk for bulk concrete structures can be erected much more quickly than brick, the construction would be more rapid.

**House of Commons.**—Sir J. Tudor Walters, Paymaster-General (Brightside, C.L.), answering a question addressed by Captain R. Terrell (Henley, C.U.) to the Minister of Health, whether he was taking any action in respect of the proposals for the construction of concrete cottages which were being submitted to him, said: An expert committee appointed by me to consider and report on the questions of standardisation and methods of construction in house building have approved 25 different methods of building cottages in concrete, and I am urging local authorities to adopt concrete construction where suitable materials are available. Tenders for some 400 concrete houses have been approved by my Department, and a number of other proposals for the erection of houses to be constructed of concrete are included among the house plans which have been approved, but which have not yet reached the stage of tenders.

**Bootle.**—The Corporation of Bootle propose erecting some eight dwellings in concrete at Orrell.

**Manchester.**—In view of the difficulty of getting the much-needed houses built of brick, the Housing Sub-Committee of the Manchester Public Health Committee have turned their thoughts to the solution of the problem by using concrete. Members of the Committee have visited districts where concrete houses have been put up, and they are inclined to ask the City Council to allow them, as an experiment, to build 300 concrete houses on the Catterick Hall Estate, Fog Lane, Didsbury.

**Birmingham.**—In connection with its housing schemes, the Birmingham Corporation has accepted tenders for the erection of 297 houses on the Yardley Wood Estate. Eighty-four of these houses will be of concrete construction, and tenders have been accepted as follows: Unit Construction Co., Ltd. (80 houses), Type E, £770; type F, £790; type G, £765; type H, £745; type Q, £755; type T, £790 each. Tarmac, Ltd. (four houses), Type G, £750 each.

**A Cottage Building Experiment.**—Having decided that they would not be justified in accepting tenders for the erection of brick cottages, owing to the excessive cost, the Bournville Works Housing Society, Ltd., has decided to experiment with other methods of construction. A sum of £7,000 has been given to the Society for the purpose, and concrete, timber and pisé-de-terre will be tried. Pairs of houses of various materials will be erected, and as the specifications will be exactly the same, in each case some useful figures regarding comparative costs should be forthcoming.

**New South Wales.**—In connection with the State housing scheme of the New South Wales Government, Mr. D. R. Hall, the Minister for Housing, is experimenting with the use of concrete.

Two concrete test houses are being built on different systems. One is to be a " pre-cast house," of which the various parts are moulded and set up in a hard state. The other is to be a " monolithic house," that is, one in which the concrete is poured into moulding boxes of the size and shape needed.

**Concrete Block Houses.**—Southgate Council has made provisional arrangements with the London Housing Board for the experimental erection of three houses in solid concrete. The houses are to be built with concrete blocks made from material at the Council's refuse destructor and rough cast outside. The cost of each house is not to exceed £750.

**Yeovil.**—The Rural District Council has received an offer for the erection of concrete houses, in lots of twenty, at the following rates: Five-room houses, £400 each; six-room houses, £500 each; seven-room houses, £525 each.

**Poole.**—The Town Council has accepted the tender of Messrs. Hill, Richards & Co. for the erection of 100 reinforced concrete cottages, at £671 per cottage, plus 10 per cent.

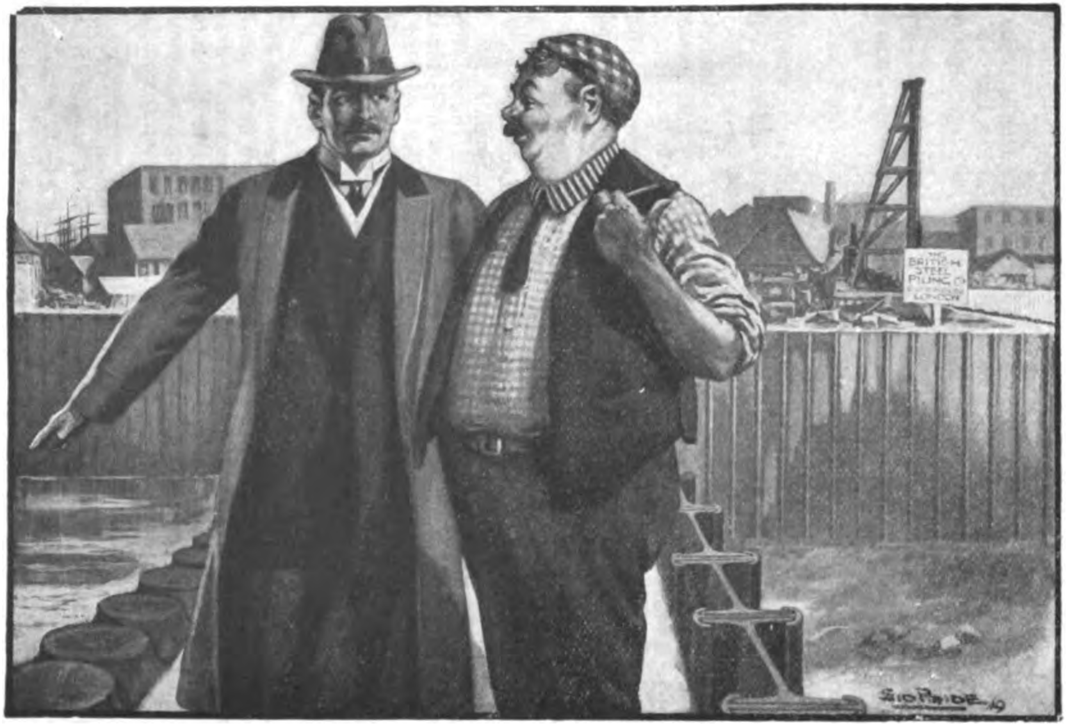
**Abersychan.**—The Abersychan Urban District Council has accepted the tender of the National Improved Housing Co., Ltd., for the erection of 248 concrete houses on the " Condual " system, at the total price of £213,735.

**Canada and Wooden Houses.**—An industrial engineer in Ottawa, who is about to build houses of concrete blocks in place of the Canadian wooden houses, of which we have heard so much, has recently written to Messrs. Winget, Ltd., as follows: " It may seem strange to you, in view of the present agitation in England for the construction of wood houses, that we in Canada should be considering the construction of concrete houses, but so it is; the high insurance now charged here for the insurance of wood houses, the high cost of painting and repairs, also the high cost of wages paid for carpenters (three times the cost before the war), compels us to find some means by which houses can be erected with the minimum expenditure for labour, insurance and repairs "

## VARIOUS.

**Reinforced-Concrete Pipes made by the Centrifugal Process.**—Concrete pipes which have been tested without serious rupture for an interior water pressure up to 400 lb. per sq. in. are being made by the centrifugal process for a number of uses in Australia and South Africa. The method of manufacture was developed by W. R. Hume, of Adelaide, South Australia. In brief, the system consists of whirling a pipe mould full of concrete on a horizontal mandrel, trusting to the centrifugal action to compact the concrete.

The pipes are being made in 4-, 6- or 8-ft. lengths. The reinforcement is of wire. In South Africa old steel winding ropes from the mines are heated, to anneal and soften the wires and to burn off grease. They are then wound in various ways upon


THE BRITISH STEEL PILING Co LONDON
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PILING CO.,
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BILLITER STREET,
LONDON, E.C.3,
FOR CATALOGUE OF
"UNIVERSALJOIST"
AND
"SIMPLEX"
STEEL SHEET PILING.

**ENGINEER.**—What is the matter with this dam—is it a blessed duck pond you're making?

**'ARRIS.**—Looks like it. That piling's no good, water pours in faster han you can pump it out.

**ENGINEER.**—That dam there is as dry as America. Why is that?

**'ARRIS.**—Ah! That piling's a bit of the right stuff. It don't let a sup o' water through, and if it does you only has to chuck a few ashes in the stream an' it's soon as dry as me. There ain't a better piling anywhere than that "Universal," it comes out as easy as it goes in, an' we can make a lot o' money in bonuses too. With that piling we can make two dams to one with t'other.

**ENGINEER.**—By Jove, it's worth getting to know about it.

**'ARRIS.**—Take my tip, sir, that piling saves money as well as makes it.

revolving cylinders the same diameter as the inside of the pipe, a sort of ropewalk being used for unwinding the strands of old rope.

The mould consists of a flexible $\frac{1}{16}$-in. steel cylinder cut in half lengthways and re-joined by hinges and clamps, so that when it is opened the pipe can be removed. This mould is placed horizontally on the rotation friction rollers of the casting machines. When a pipe is to be made, the steel wire reinforcement is placed inside the mould. Flanges, the same depth as the required thickness of the pipe walls, are placed on the end of the mould, and wet concrete of various grades corresponding to the quality of the pipe required is introduced from the ends, which are open except for the flanges mentioned. The pipe is revolved slowly at first, and the concrete is automatically distributed evenly along the whole length of the pipe and around the circumference, and completely incases and embeds the reinforcement.

The pipe is then revolved more rapidly, and the excess water, with any impurities, is collected in the centre of the pipe and drawn off at the ends. The concrete by this time has set so hard that it is impossible to make an impression on it with the finger. The moulds are run into a steam house for 24 hours and then opened, and the pipes are seasoned in water tanks for a month, usually. Pipes can, however, be put in use within a week.

The pipes show a remarkable density, and are impervious to great pressure either in sections or as a continuous line. A joint as strong as or stronger than the main itself has been designed. The ends of the pipes are recessed and butted together, forming a diamond-shaped cavity between them. A collar 6 in. wide, of strength similar to that of the pipe, is put on and secured with a backing of cement at both ends. Between the pipe a plastic bituminous cement is inserted, and pressure tends to compress this in the annular cavity of diamond-shaped section. This makes a joint which has been tested to 400-lb. pressure. Experiments show that a pipe designed for 100-lb. pressure shows at 200 lb. faint lines of dampness; at 250 lb. this becomes a dew. At 300 lb. the dew develops into a heavy sweat, and at 350 lb. jets of the finest misty spray appear. If this pressure is reduced the pipe takes up and is as capable as before of carrying 100-lb. pressure.—*Engineering News-Record.*

**Sailors' Hostel.**—A sailors' hostel is to be erected in Commercial Road opposite Limehouse Town Hall. The hostel is to be built as a memorial to the seamen and firemen of the British Mercantile Marine who lost their lives during the war. The building is to be of reinforced concrete construction throughout, and has been designed by Mr. Brammal Daniel, of 75, Mark Lane, E.C.

**Concrete Pipes.**—It was recently reported in the *Times* that a plan is under discussion to construct pipes of concrete along the railway line from Havre to Paris, which will be used to bring the new fuel mazout (crude oil) to Paris instead of coal.

**Concrete Sleepers.**—We learn that Col. H. F. Stephens, R.E., is now making from 60 to 70 concrete sleeper blocks per week for the Weston, Clevedon and Portishead Light Railway. Particulars of this work were given in our issue of October last.

## TRADE NOTES.

**The Hy-Speed System of Construction.**—The Patent Hy-Speed System of housing consists essentially of slabs, made of any known building material, but preferably of concrete, and adapted to fit into vertical dovetail or other grooves, formed in suitable piers, or columns, built up of special clutches, the whole arrangement permitting the use of cheap breeze or other plain slabs, such as stock paving flags, breeze partition, or any other kind of slabs, to enter very largely into the construction of these buildings which can be erected by unskilled labour.

The structure is tied together by clutches which form piers, or buttresses, and tying slabs which interlock with the clutches. The clutches have a hole cored in to receive a vertical armouring rod which is grouted into position when they are assembled. Each clutch has a recess for a wood or other fillet, which carries the inner wall-board, lining or panelling as desired.

The horizontal edges of the slabs rest on each other, and are jointed with cement and their vertical joints fit in the dovetail grooves formed in the buttresses built up of clutches. The slabs may be pre-cast or formed in situ by using suitable reinforcing material.

For full particulars apply to Hy-Speed Housing Patents, 244, Stockport Road, Gee Cross, Hyde, Manchester.

### NEW COMPANIES REGISTERED.

Concrete Dwellings, Ltd. (161,328).—Registered December 5th, 1919. 5 and 6, Great Winchester Street, E.C.2. To carry on the business of builders and manufacturers of constructional material and apparatus. Nominal capital, £10,000, in 10,000 shares of £1 each. Directors to be appointed by subscribers. Qualification of directors, other than first directors, £100; remuneration of directors, £100 each; chairman, £150.

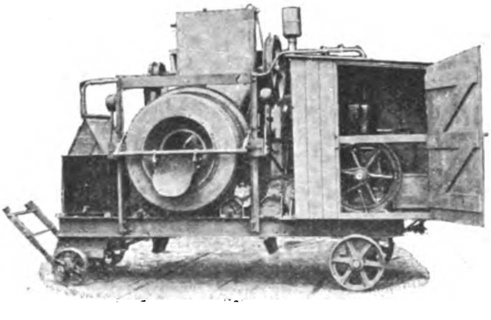
D. P. W. House Construction Co., Ltd. (161,353).—Registered December 6th, 1919. 88, Ronald Park Avenue, Westcliff-on-Sea. To carry on the business of house builders and public works contractors, &c. Nominal capital, £2,500 in 2,000 8 per cent. cumulative preference shares of £1 each and 10,000 deferred shares of 1s. each. Directors to be appointed by subscribers. Qualification of Directors, 100 shares; remuneration to be voted at general meeting.

British Lock Slab Construction Co., Ltd. (161,464).—Registered December 10th, 1919. Prudential Buildings, Market Place, Dewsbury, Yorks. To carry on the business of merchants and dealers in concrete slabs. Nominal capital, £10,000, in 10,000 shares of £1 each. Directors: W. H. Ellis, 13, Oxford Street, Dewsbury; A. Hinchcliffe, 14, Regent Street, Barnsley; N. E. Hartley; and J. Thawlis. Qualification of directors, £2,500; remuneration, £100, to be divided.

Standardised Construction Development Co., Ltd. (161,448).—Registered December 9th, 1919. 14-16, Cockspur Street, S.W.1. To carry out experiments with materials of all kinds with a view to the manufacture of the same into building material. Nominal capital, £10,000, in 10,000 shares of £1 each. Directors: C. Ourzman, M.B.E., Stratton Villa, Croydon Road, Anerly, S.E.; P. Wright, 75, Cromwell Road, S.W.; and E. Read, 2, Church Lane, Ealing, W. Qualification of directors, 500 shares; remuneration to be voted at a general meeting.

Williams Structures, Ltd. (161,593).—Registered December 12th, 1919. 28, Victoria Street, Westminster, S.W. To carry on the business of general contractors, and in particular the construction and equipment of railways, tramways, aqueducts, canals, &c. Nominal capital, £200,000, in 200,400 shares of £1 each. Minimum subscription, £7. Directors: E. J. Metcalf, 5, Chester Place, Hyde Park, W.2; and P. E. Hill, 10, Queen Street, Mayfair, W.1. Qualification of directors, other than first directors, £250; remuneration, £300 each.

Waller Housing Corporation, Ltd. (161,648).—Registered December 13th, 1919. 16, Albemarle Street, W.1. To carry on the business of building and general contractors. Nominal capital, £250,000, in 250,000 shares of £1 each. Minimum subscription, £7. Directors: E. J. Metcalf, 5, Chester Place, Hyde Park, W.2.; The Rt. Hon. E. Coke, 8, Park Street, W.2; and P. R. Hill, 10, Queen Street, W.1. Qualification of directors, £250; remuneration, £500 each.



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# CONCRETE AND CONSTRUCTIONAL ENGINEERING

FEBRUARY 1920. VOL. XV. No. 2.

***A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.***

*ISSUED MONTHLY*

## CONTENTS.

**Editorials.**

**Reinforced Concrete Grain Silo, Hull.**

**Problems in the Theory of Construction:**
Rigid Reinforced Concrete Frames.
By EWART S. ANDREWS, B.Sc.Eng., etc.

**Concrete Cottage Building at Dormanstown.**

**Notes on a Suggested Solution of the Housing Problem:**
By a CIVIL ENGINEER.

**The Place of Concrete in the Coming Era:**
On the North American Continent. *(Concluded.)* By EDWIN TOMLIN.

**The Main Road from Newport to Cardiff.**

**The First Reinforced Concrete Freight Car.**

**Modern Methods of Concrete Construction:**
By an ANGLO-AUSTRALIAN RESIDENT ENGINEER.

**Reinforced Concrete Sewers and Conduits.**

**Concrete Ash Receivers.**

**Recent Views on Concrete and Reinforced Concrete:**
The Use of Elliptical Vaulting as a Primary Factor in Contemporary Architecture.
By MAURICE S. R. ADAMS, A.R.I.B.A.
Warehouse Design. By HENRY ADAMS, M.S.A., M.Inst.C.E., etc.

**Practical Notes on Problems in Construction.**
By Dr. OSCAR FABER, D.Sc., etc.

**Concrete Shipbuilding.**

**Questions and Answers Relating to Concrete.**

**The Foreign Press.** **New Books.** **Memoranda.**

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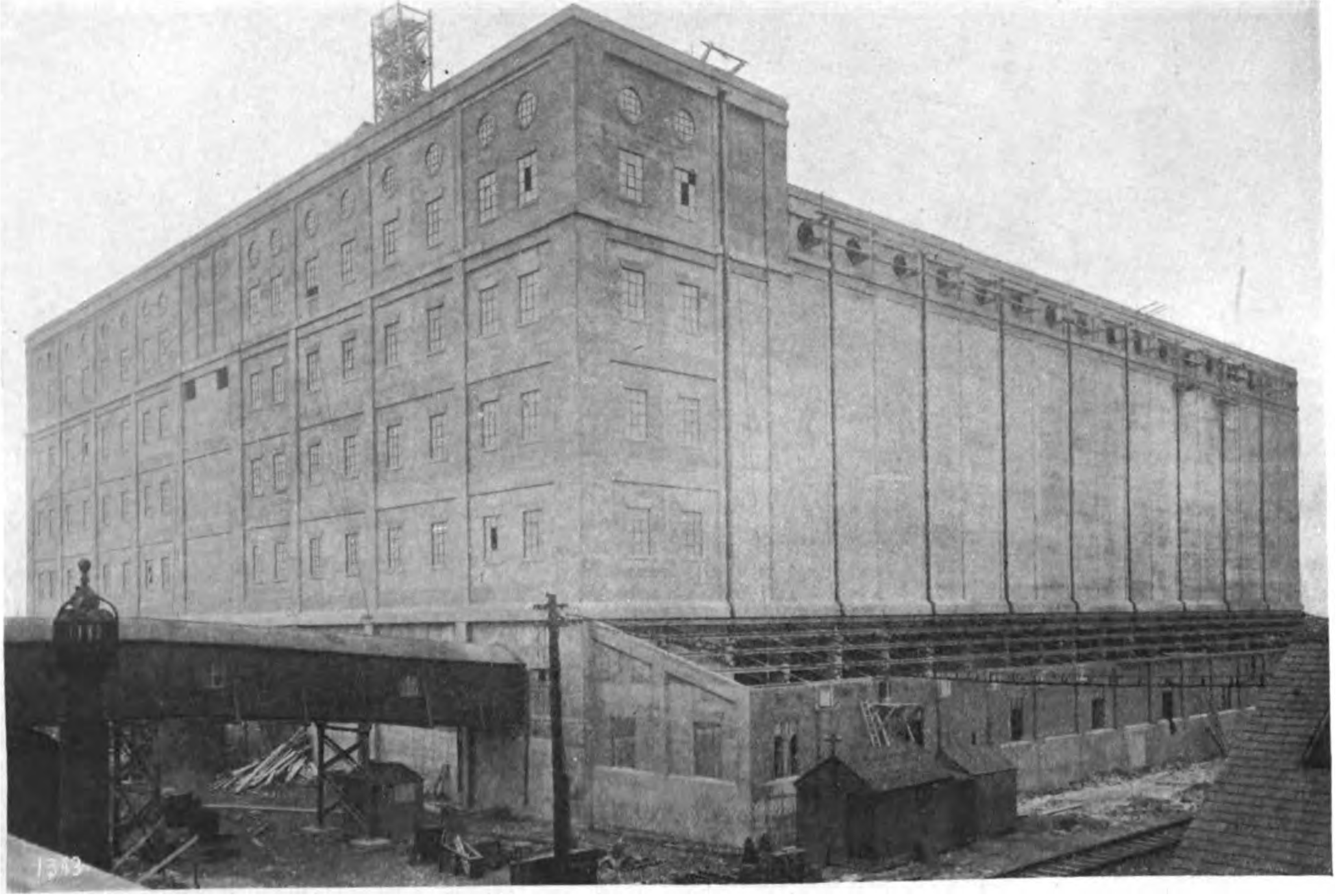

Reinforced Concrete Grain Silo, Hull.
*(For description see page 75)*

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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# *EDITORIAL NOTES.*

## ELLIPTICAL VAULTING AS A FACTOR IN ARCHITECTURE.

### CONSTRUCTION AND ORNAMENT.

THE relation of construction to ornament is a matter fraught with difficulties and complexities of all kinds, and it is doubtful whether the degree of intimacy between the two may be made the measure of good architecture. The whole subject being, indeed, one into which the human element so emphatically enters, it becomes unwise to dogmatise, and it is therefore not surprising to find that several speakers disagreed with certain of the more sweeping generalisations made by Mr. Maurice S. R. Adams in the course of the paper on " The Use of Elliptical Vaulting as a Primary Factor in Contemporary Architecture," which he read before the Concrete Institute on December 18th.

Even the assertion that it is bad architecture for one material to disguise itself as another cannot be accepted too literally. Must St. Mark's at Venice be condemned because it is a brick building veneered with marble ? Yet, few would be found willing to defend the pernicious habit of imitating half-timber work with ⅜-in. boarding. Custom and tradition are important factors which cannot be ignored, and architecture, like mankind, is the result of all that has gone before ; the present is but the past ever projecting itself into the future. We accept and admire the classic forms, yet realising that from the time they were appropriated by the Romans and combined with their own forms of the arch and vault, they were robbed of the real constructional significance which they possessed as an integral factor in a purely trabeated style.

### NATURE AND ARCHITECTURE.

Neither can a standard of architectural excellence be deduced from the forms or acts of nature. Indeed, it may with considerably more justification be said that the progress of civilisation is just the measure of man's success in combating and overcoming nature. The utilitarian origin of architecture is to be found in man's desire for protection against the ravages of nature. And the difficulty with which he found himself immediately faced arose from the natural forces : the wind, the sun, and the action of frost and the like, and her immutable laws, such as gravity and the expansion and contraction of matter with every change of temperature. Furthermore, the prodigality of Nature is an example which we should be ill-advised to emulate, either in our architecture or elsewhere.

### LOGIC NOT THE BASIS OF ARCHITECTURE.

It is the fact that good architecture depends upon something ineffable and elusive, something which evades the confines of logic, and which seems to originate from that part of ourselves from which emanate our absolute standards of goodness and beauty, that makes it seem doubtful whether the architectural forms suggested by Mr. Adams will satisfy our needs, despite the fact that from a logical, and possibly constructional basis they may be entirely satisfactory. And this is indicative of no mere prejudice against novelty. To convince the intelligence will not suffice. No assurance, by whatever erudite calculations, as to the security of a vast building apparently resting upon a sheet of plate glass, as may be so often seen in large shops, will satisfy the eye, which demands some adequate mass in the guise of piers to carry the superstructure. Similarly, although a vault springing from the ground may be structurally sound, economical, and easy to erect, we are so accustomed to vertical lines, both in our buildings and in all the objects around us, that we should find great difficulty, even were we so disposed, in reconciling ourselves to their loss. And if a superabundance of luxury and ornament about our buildings may disgust us, so too will an exaggerated simplicity leave us unmoved, for man rejoices in delicate workmanship and rare materials. That it may be expedient at the present time to curtail expenditure, there is no gainsaying, but to pretend that such a course is in itself desirable is merely to make a virtue of necessity.

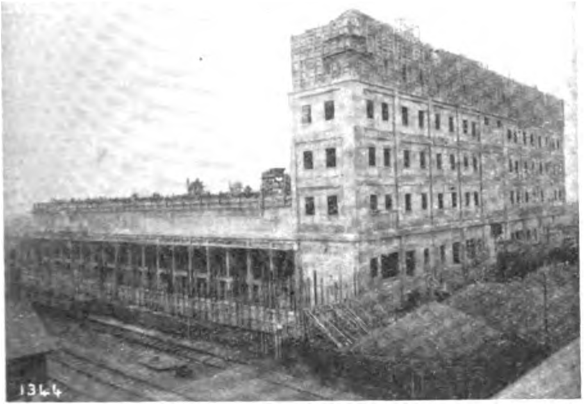
### PRACTICAL CONSIDERATIONS.

Of the various types of buildings touched upon by Mr. Adams in the course of his paper, it would appear that his system of elliptical vaulting could be most effectively used for factories, workshops, sheds and similar buildings in which a large and unobstructed floor space is required, and in work of this kind the purpose of the buildings might be well expressed in the simple lines and curves which such a method of construction would yield.

The vault itself might be adapted for church architecture, but for the reasons already stated it would need to be carried on walls and piers. The curve rising direct from the ground would at once suggest a reversion to primitive architectural forms. The Gothic builders, for whom Mr. Adams appears quite rightly to have an immense—if, alas, a somewhat unfashionable—admiration, seemed rather to rejoice in the structural complexities which the natural development of their work involved, becoming ever more audacious, and introducing that beautiful and original feature, the flying buttress. To have sprung their vaults from the ground would surely have been an evasion, but no solution, of the problem, and it would certainly have been but a poor expression of the great aspirations which seemed ever to inspire their work.

It is doubtful if elliptical vaulting can be considered suitable for cottage building. Furthermore, the addition of a second storey seems to present certain difficulties which have yet to be overcome.

The idea which Mr. Adams has developed may be made of great service, but this can best be done by co-ordinating it with existing customs, ideals and aspirations. The architectural tradition can be developed, but it cannot be broken. It is almost platitudinous to observe that the greatness of an artist is to some extent to be measured by his realisation of the limitations of the medium in which he works. So, too, ideas, especially where, for their realisation they require objective form, are limited in their application.



# THE GRAIN SILO, KING GEORGE DOCK, HULL.

*The following brief description of the large Grain Silo at Hull is an interesting example of the use of reinforced concrete for buildings of this description.—ED.*

---

THE grain silo, which is situated at the west end of the north-west arm (No. 2 Quay) of the King George Dock, Hull, has been erected by the Hull Joint Dock Committee (North Eastern and Hull and Barnsley Railway Cos.), and has a capacity of 40,000 tons of grain.

The building is constructed in reinforced concrete throughout, and built in two blocks, each 96 ft. wide and 241 ft. long.

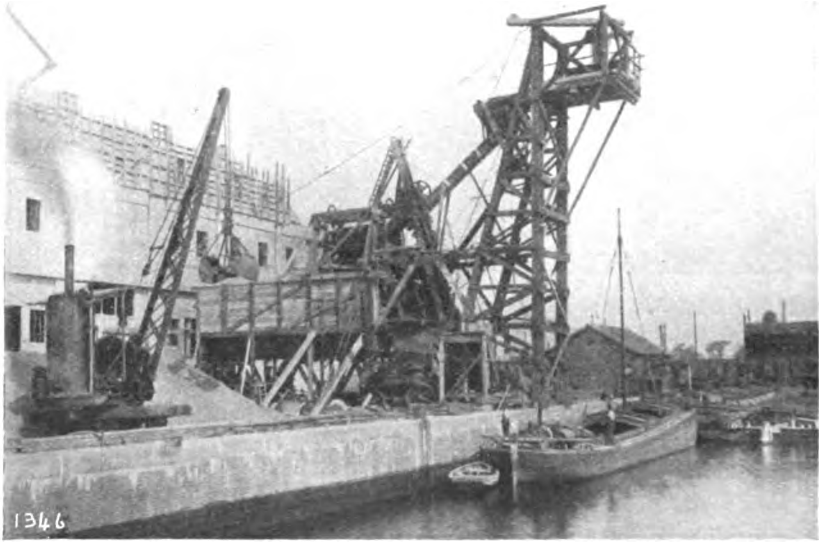
The receiving houses, which extend to 98 ft. above quay level, are situated at the front of each block for housing the elevators, weighers, separators, etc. The basements of the receiving houses are connected with the distributing chamber, which is underground, and occupies the whole of the space between the main building and the quay wall (90 ft.), and is in turn connected to two subways, extending 900 ft. along Nos. 1 and 3 Quays respectively, thus providing four 450 ft. grain ship berths ; these subways are supported on timber piles.

Each block of the main building consists of 144 equal storage bins, spaced 12 ft. centres, and having a depth of 50 ft.

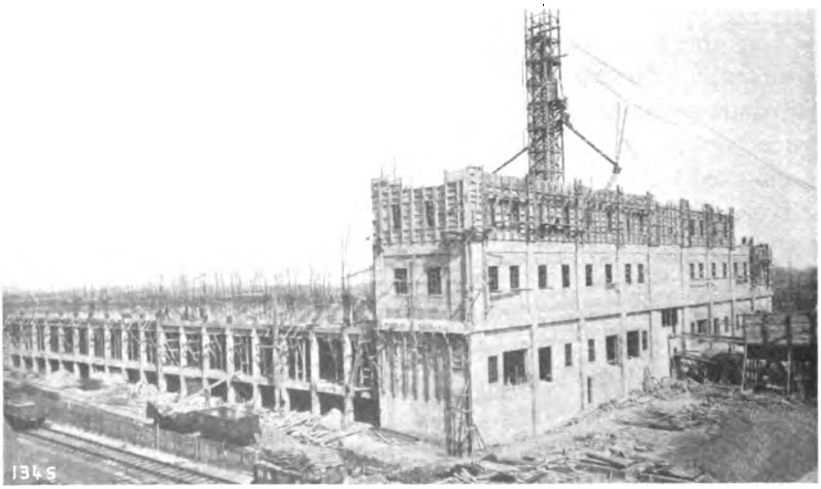
Below the bins are two floors ; the ground floor for the storage of grain in bulk or bags, and the first floor (below bin hoppers) for sacking off grain from the bins.

The two blocks are provided with a floor over the bins for grain distribution to the bins, and are connected by two covered-in bridges.

In connection with the sacking-off floors, three covered-in wagon ways are provided for the full length of the building (one between the two blocks and one at each side) for the distribution of grain by rail. There are also four overhead gantries leading from the front of the receiving houses to the west end of the dock arm (No. 2 Quay), for dealing with grain, either in bulk or in bags, to barge or other craft.



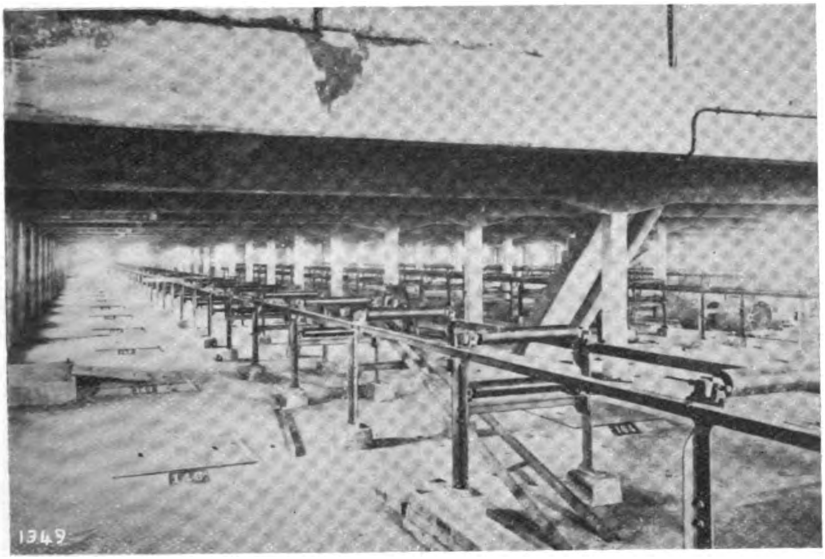
Ballast Handling Plant.



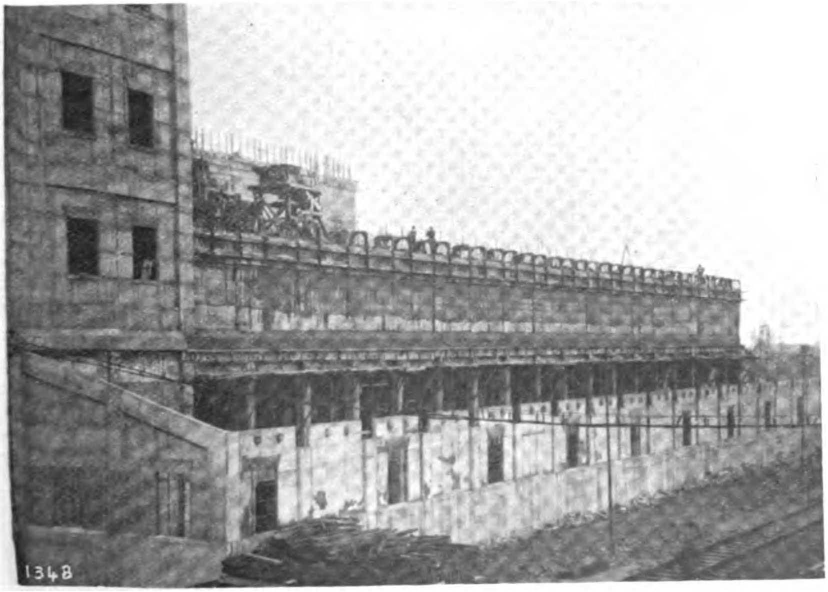
Building in course of construction.
Reinforced Concrete Grain Silo, King George Dock Hull.

Between the two blocks, and joining the two receiving houses, are situated the dust chamber and switch room.

Below each block are two subways, extending the full length of the building. These subways connect with the distributing chamber, and contain conveyors for the redistribution and cooling of grain.



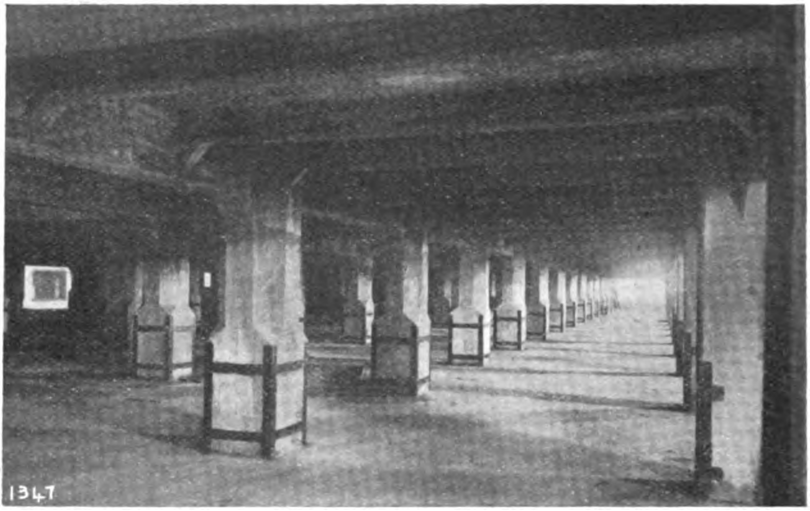
Floor over top of Bins.



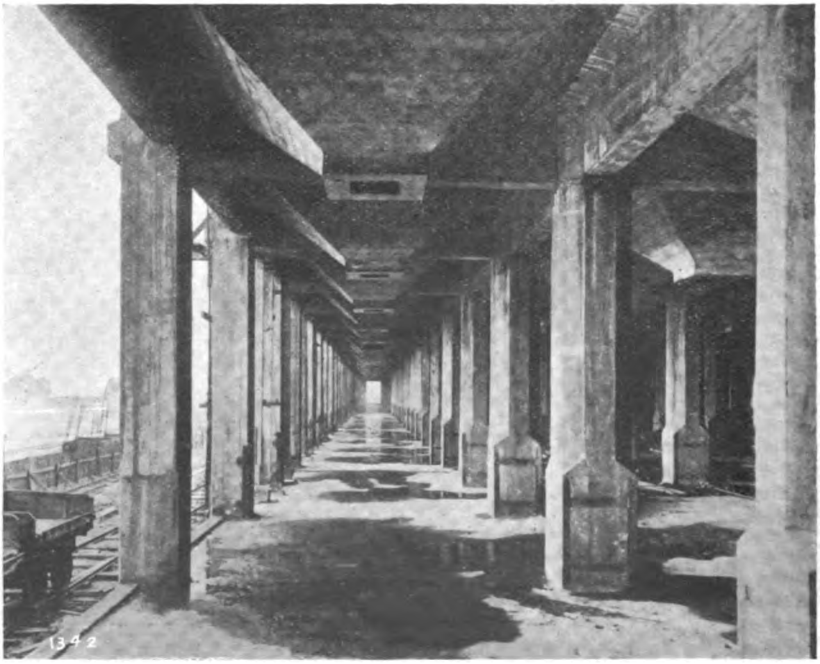
View of Silo in course of construction.
REINFORCED CONCRETE GRAIN SILO, KING GEORGE DOCK, HULL.

The structure is supported on reinforced concrete footings and groups of 15-in. reinforced octagonal piles, varying in length from 45 ft. to 60 ft.

The distributing chamber and the basements of the receiving houses are 12 ft. to 16 ft. below high-water level. All floors, roofs, and walls below quay level have been made impervious with bitumen dressing.



Ground Floor under Sacking Floor.



Reinforced Concrete Grain Silo, King George Dock, Hull.

The ground and sacking-off floors, together with the roofs, have been covered with asphalte, composed of a mixture of Trinidad lake bitumen, rock asphalte, and granite chippings.

The conveyer subways under Nos. 1 and 3 Quays and the concrete piles are reinforced on the Considère system, and the remainder of the work on the British Reinforced Concrete Engineering Co.'s system.

The contractors for the foundations and for the quay subways were Messrs. S. Pearson & Son, Ltd., and for the main building the British Reinforced Concrete Engineering Co., Ltd., who dispensed with the ordinary "shuttering" when constructing the bins, and used moving forms for the full height (50 ft.) of the bin walls.

The building was designed by the engineers to the Hull Joint Dock Committee, and carried out at first under the supervision of the late North Eastern Railway Docks engineer, subsequently being supervised by the chief engineer of the same company.

# PROBLEMS IN THE THEORY OF CONSTRUCTION.

## RIGID REINFORCED CONCRETE FRAMES.

By **EWART S. ANDREWS**, B.Sc.Eng.; M.C.I.

*Introduction.*—The stresses in rigid reinforced concrete frames can only be calculated either by assuming with more or less accuracy the position of the points of inflection or else by the application of the complicated mathematical analysis based upon Castigliano's Theorem of Internal Work.

An important contribution to the subject has recently been given by the publication of Bulletin No. 107[*] of the Illinois Experimental Station, by Dr. M. Abe, upon "Analysis and Tests of Rigidly-Connected Reinforced Concrete Frames."

Dr. Abe gives in condensed form the method of analysis involved in the calculation of stresses in rigid frames of this kind, tables of formulæ being given for a number of types of frames and conditions of loading; he then proceeds to give the principal results of his tests, with photographs of the specimens after test showing positions of cracks developed, and finishes with a summary of general conclusions of the experiments.

The bulletin, which occupies 102 pages, is written in the concise style, which is characteristic of modern American publications upon the subject, but which makes the paper rather heavy reading for the engineer already possessing some knowledge of mathematical analysis and almost unintelligible to the ordinary practising engineer without such knowledge.

In our opinion Dr. Abe would have given very great assistance to practising engineers, who have to design such structures and accept responsibility for them, if he indicated approximations in calculations which would not result in greater error than his experiments indicate to be involved necessarily in the calculations. In making this observation we do not wish to detract from the value of the very fine piece of work which Dr. Abe has carried out; we wish rather to point out the weakness which most research workers possess of attempting to prove experimentally the truth of complicated theories, rather than of simplifying such theories for the needs of practical design.

In the present article we hope to give the principal results of Dr. Abe's paper and to explain, as fully as the space available will allow, the methods of calculation which problems of this nature involve.

---

[*] London, Chapman & Hall, Ltd.

GENERAL CONCLUSIONS OF EXPERIMENTS.—We will reverse what might be regarded as the natural order of things by giving first the author's conclusions ; they are as follows :

(1) Considering the errors involved in the measurement of the deformations and in the determination of the modulus of elasticity of the concrete, as well as those due to assumptions with reference to the distribution of stresses across the section and over the gauge length, the results presented indicate a fair agreement between analyses and tests and justify the conclusion that the formulæ given in the bulletin for statically indeterminate stresses as applied to reinforced concrete structures will give values for stresses in the members well within the limit of accuracy required in design.

(2) The elastic action of the frames under external load and the manner of stress distribution along the members of the frame agree fairly well with the analyses given.

(3) The location of the point of inflection in the members of the frames under load agrees closely with the location found by analyses.

(4) If a frame is carefully designed and well reinforced, there need be no anxiety as to rigidity of a joint. Effective continuity of members has been found in the tests.

(5) No sudden failure took place in the frames tested. The increase in the deflection was uniform, indicating as great reliability for reinforced concrete frames as for steel structures.

(6) The load at which the first fine crack appears near the juncture of members is increased by fixing the lower column ends of a frame. This is obviously due to the increase in horizontal thrust at the lower column end over that developed when the lower end is free to turn.

(7) At sharp inside corners, high compression stresses were developed in the concrete due to so-called curved beam action and in several cases local failure occurred by the crushing of the concrete at these corners under high loads.

(8) A slight deviation of the axis of vertical members from a vertical line, that is to say, a slight "out-of-form" of the vertical columns, produced an appreciable variation in the stress distribution in the frame.

(9) Owing to the existence of a horizontal thrust (which varies from $\frac{W}{8}$ to $\frac{W}{18}$, $W$ being a concentrated load, in most common cases of simple frames) at the ends of a vertical or inclined member, it is advisable to incline the member slightly towards the direction of the reaction at the end. Such arrangement will greatly reduce the bending stress in the member. If this arrangement is not practicable, a slight increase in the top width of a vertical member and a slight decrease in its bottom width, brought about by inclining the inner surface and making the outer surface vertical, will add materially to the rigidity of a frame without a proportional increase in the amount of material used.

(10) For a frame having an inclined column, it may be possible to select the form of frame in such a way that the column will take no bending stress throughout its length.

(11) Due attention should be paid to the rigid joint of a tie member to insure the stiff connection with a main member. A marked tendency to cause a sudden breaking of such a joint accompanied an increase of bending moment in a main member.

(12) The use of a footing rigidly connected to the lower end of a vertical member is advisable, for it will reduce the bending moment at the juncture of the vertical and inclined members. A frame having such a footing is solvable analytically, since it approaches the case half way between that of the hinged end and that of the fixed end of the vertical member, provided the foundation is sufficiently unyielding. A little consideration is needed to provide proper reinforcement at the junction of the column and the footing.

(13) The formulæ derived by analysis may be applied to a variety of forms of frames and are of wide applicability.

METHOD OF CALCULATION.—Rigid frames are among the class of structure which are classified as "statically indeterminate." The stresses in such structures may be determined by Castigliano's Theorem* which is as follows:

*If we express the internal work of a body or elastic structure as a function of the external forces, the differential coefficient of this expression, with regard to one of the forces, gives the relative displacement of its point of application.*

In the problem under consideration we require to calculate the horizontal thrust $H$ at the supports and the displacement at these points is zero, so that by differentiating the internal work with reference to $H$ and equating to zero, we obtain an expression from which $H$ can be calculated.

This gives us the following equation, neglecting the internal work due to direct thrust and shear, which is relatively small :—

$$X = \int \frac{B}{EI} \cdot \frac{\delta B}{\delta H} \cdot dx = 0 \qquad (1)$$

In this equation

$X$ = Horizontal displacement of point.

$B$ = Bending moment at a point at distance $x$ from the origin.

$E$ = Elastic Modulus.

$I$ = Moment of Inertia.

APPLICATION TO SIMPLE PORTAL FRAME.—We will take one of the forms of frame tested in the research under notice, derive the formulæ and consider the results of the tests. This frame is illustrated in *Fig.* 1; the loading being by means of two isolated loads symmetrically placed along the top beam. We will call $I_c$ the moment of inertia of the column (assumed for the purpose of calculating the horizontal thrust to be constant) and $h$ its height; the moment of inertia of the beam we will call $I_B$ and its length $l$.

We will also take $\frac{I_B}{l} \div \frac{I_c}{h} = s$ = stiffness coefficient; Dr. Abe does not use this symbol which assists materially in giving a simple appearance to the resulting formulæ; at a later stage in the Bulletin (p. 44) a somewhat similar simplification is, however, made.

Since the two halves of the rigid frame are exactly alike we need only consider the integration over half the frame—*i.e.*, from $A$ to $C$.

---

*A translation by the present writer of Castigliano's book, entitled "Elastic Stresses in Structures," has recently been published by Messrs. Scott, Greenwood & Son, London.

We then have :—

*Column.* $B=Hx \quad \therefore \ \frac{\delta B}{\delta H}=x$

$$\therefore \ X_1=\int_0^h\frac{Hx}{EI_c}\cdot x dx=\frac{H}{EI_c}\int_0^h x^2dx$$

$$=\frac{Hh^3}{3EI_c} \qquad (2)$$

*Beam.* From $B$ to $E$, $B=Hh-\frac{Wx}{2}$

$$\therefore \ \frac{\delta B}{\delta H}=h$$

$$\therefore \ X_2=\int_0^a\frac{Hh-\frac{Wx}{2}}{EI_B}\,.\,h\,.\,dx$$

$$=\frac{h}{EI_B}\int_0^a\left(Hh-\frac{Wx}{2}\right)dx$$

$$=\frac{h}{EI_B}\left(Hha-\frac{Wa^2}{4}\right) \qquad (3)$$

From $E$ to $C$, $B=Hh-Wa$

$$\therefore \ \frac{\delta B}{\delta H}=h$$

$$\therefore \ X_3=\int_0^{\frac{l}{2}-a}\frac{\left(Hh-\frac{Wa}{2}\right)}{EI_B}h\,dx$$

$$=\frac{h}{EI_B}\left(Hh-\frac{Wa}{2}\right)\left(\frac{l}{2}-a\right) \qquad (4)$$

$$\therefore \ X_2+X_3=\frac{h}{EI_B}\left\{Hha-\frac{Wa^2}{4}+\frac{Hhl}{2}-Hha-\frac{Wal}{4}+\frac{Wa^2}{2}\right\}$$

$$=\frac{h}{EI_B}\left\{\frac{Hhl}{2}+\frac{Wa^2}{4}-\frac{Wal}{4}\right\}$$

$\therefore$ Since by equation (1) $2\,(X_1+X_2+X_3)=0$, we have

$$\frac{Hh^3}{3EI_c}+\frac{h}{EI_B}\left\{\frac{Hhl}{2}-\frac{Wa}{4}(l-a)\right\}=0$$

$\therefore$ dividing through by $\frac{h}{E}$

$$H\left\{\frac{h^2}{3I_c}+\frac{hl}{2I_B}\right\}=\frac{Wa}{4I_B}(l-a)$$

$$\frac{Hhl}{I_B}\left\{\frac{h}{3I_c}\cdot\frac{I_B}{l}+\frac{1}{2}\right\}=\frac{Wa}{4I_B}(l-a)$$

$$Hhl\left\{\frac{s}{3}+\frac{1}{2}\right\}=\frac{Wa}{4}(l-a)$$

$$\therefore \ \frac{Hhl}{6}(2s+3)=\frac{Wa}{4}(l-a)$$

$$\therefore \ H=\frac{3Wa\,(l-a)^*}{2hl\,(2s+3)} \qquad (5)$$

The B.M. diagram is then as shown, bending moments which cause tension on the outer side of the beam being regarded as negative.

*(To be concluded.)*

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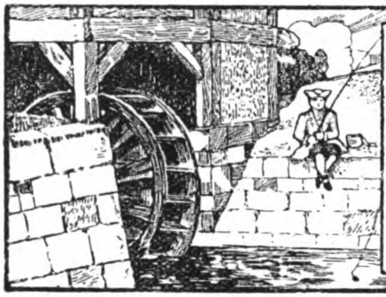
* For a derivation of this formula by means of the formula for arches with hinged end, see the writer's book upon "Further Problems in the Theory and Design of Structures," p. 202.



# CONCRETE COTTAGE BUILDING.

## DORMANSTOWN.

Of the many criticisms which are levelled against concrete construction for cottage building, most of which are, indeed, but the result of ignorance or prejudice, one of the most justified is that which is based upon æsthetic considerations. It is stated, and often quite truly, that concrete cottages are for the most part of an unprepossessing appearance, and that the material does not permit of a variety of treatment, such as may be obtained from the use of the more familiar brick. The situation at Dormanstown, therefore, is one of unusual interest, for a comparison may be made between the recently completed brick and concrete houses, which form part of one of the most extensive housing schemes in the north of England, which it is intended will ultimately include some 3,000 houses.

The first 300 houses of this new village were built during the war by Messrs. Dorman, Long & Co., of Middlesbrough, to house the employees of their new works at Redcar, in Yorkshire. The architects were Messrs. Adshead & Ramsey, with whom was associated Prof. Patrick Abercrombie. The village, of which a lay-out plan is shown in *Fig.* 1, is separated from the works by a stretch of open common, and the arrangement is that of a symmetrically disposed village on either side of a large open green, which is approached from the town by a wide avenue. These first 300 houses were built of brick, the designs being on simple and traditional Georgian lines with carefully proportioned doors and windows in harmony with the general tone of the surrounding villages.

When recently, however, Messrs. Dorman, Long & Co. wished to proceed with the development of their village, they decided to adopt an entirely new method of construction, in order to be independent of the many building materials which are both scarce and costly, and to be free from the many difficulties which they had experienced during the course of the erection of the first instalment of brick cottages. As a result of much careful thought and experiment, they have evolved a method of construction altogether unique, and by its means they have been able to overcome these many difficulties, with which they had previously been faced. Realising, however, their own limitations as constructional engineers, they retained the services of their architects in the designing and planning of the houses.

The basis of the construction is a steel frame encased in Hy-Rib expanded metal, which forms the reinforcement for the concrete outside walls, the inside walls being of slabs. Timber and bricks are almost dispensed with. The erection of the steelwork presents no difficulty. Great speed is obtainable by

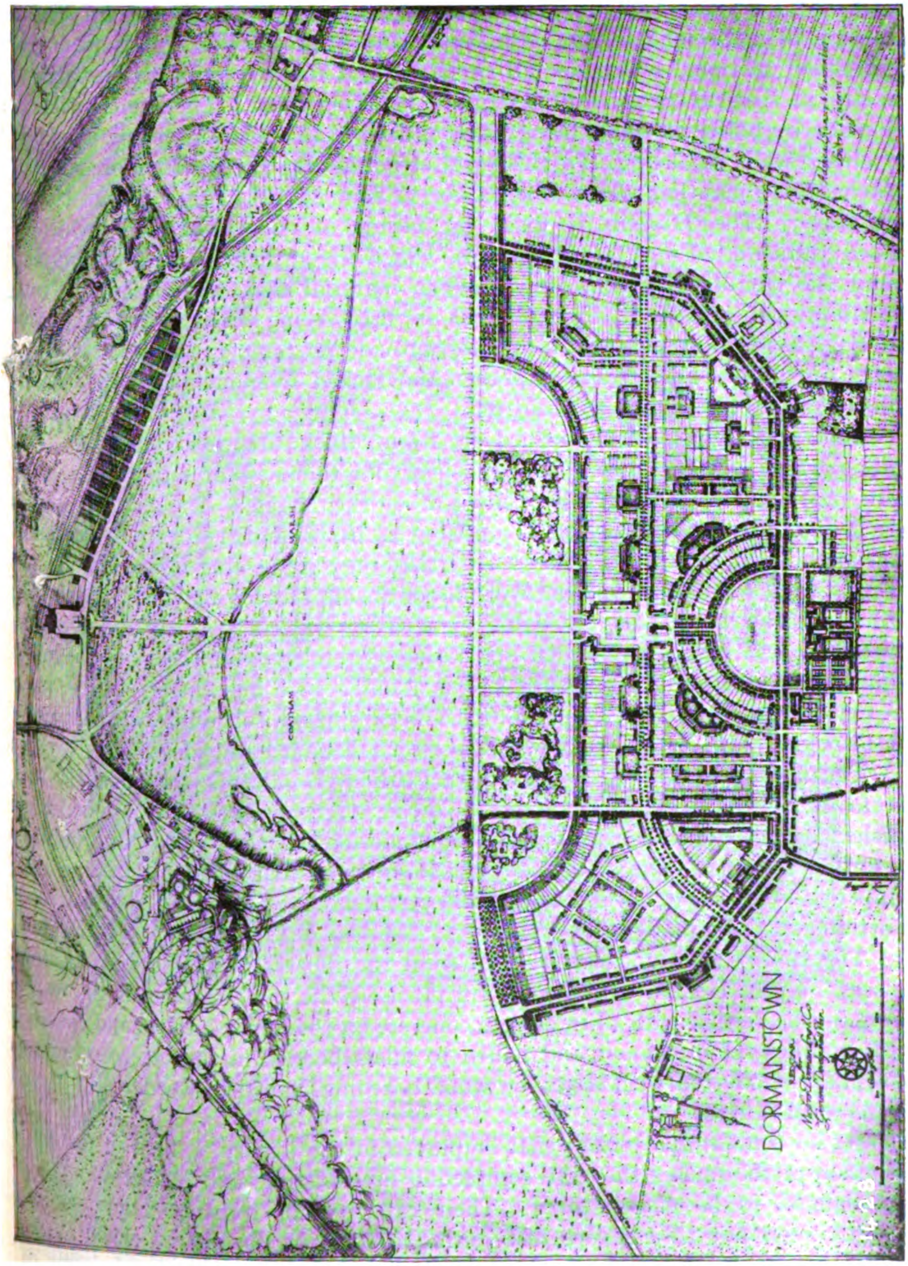


Fig. 1 A General Layout of the Village of Dormanstown.
Concrete Cottage Building.

means of proper organisation, particularly, of course, in districts where sand and aggregate are easily obtainable. The steel structure of the house is fixed by means of a steel cill, attached by Lewis bolts to the concrete foundations. *Fig.* 2 shows the framework of a pair of houses which was erected by four men in three days without the aid of mechanical device. This framework, which has been patented by Messrs. Dorman, Long & Co., is treated against corrosion in a special manner, both before and after erection. It is formed of light rolled sections, which are all prepared and marked prior to despatch to the site, so that no special skill is required in fixing them. The site connections are made by bolts, no rivets being used, and no close shuttering being employed for either walls or floors. To this steel structure the Hy-Rib reinforcement is attached, an operation which takes three or four days. *Figs.* 3 and 4 show this stage. The Hy-Rib is fixed by means of galvanised wire, which is passed through holes at 21 in. centres, which are drilled in the uprights and round the rib of the reinforcement. The material is fixed horizontally with the rib inward, and 3/16 in. diameter rods are used, being wired at right angles to the Hy-Rib at 30 in. centres, in order to provide for temperature stresses. T[illegible] sheets are lapped and pressed together and locked by punching with a handl punch every 24 in. and at the centres.

The walls, which when finished are 8¾ in. thick, are then concreted. The outer portion of the hollow wall is finished to a thickness of 2 in., made up of 1½ in. on the inside of the Hy-Rib, and ½ in. on the outside. The mixture used is 1 to 4 of cement and aggregate, comprising 2½ parts sand, 1½ parts fine crushed slag, and 1 part cement. It is essential that the slag be free from sulphur and lime. The inner portion of the wall on the inside face of the steel uprights is formed of coke breeze concrete slabs. The cavity is 4½ in. As Hy-Rib is a self-centering material, close-boarded shuttering is rendered unnecessary, the only requirement being temporary supports at about 2 ft. 6 in. centres. These may be removed so soon as the inside coat has been applied. The internal partitions are formed of coke breeze slabs with a plaster finish on both sides.

The first floor is constructed of steel transverse beams, to which Hy-Rib sheets are fixed on the top side. Two inches of concrete is then applied and finished with patent flooring or cement rendering, which is taken up the wall to form a skirting. The underside is also finished with cement screeding distempered in the usual way. For the construction of the floors no close-boarded shuttering is necessary.

The roof, which, as may be seen from the illustration, is carried on steel trusses, may be treated with Hy-Rib in precisely the same manner as the walls, being finished either with 1¼ in. breeze concrete on the upper surface, and covered with pantiles set in cement and nailed to fillets bedded in the breeze concrete, or it may be covered with slates on wood boarding, nailed to wooden slips fixed to the steel rafters.

As no timber, apart from that employed in the joinery, is used in the construction of the houses they are completely fire-resisting, and furthermore, they are claimed to be vermin-proof. Their capacity for resisting dampness has recently been put to a severe test during a storm in the district, when heavy rain, accompanied by a north-east gale, continued for many days. In some of the brick houses dampness was noticeable, whereas the steel-framed houses remained absolutely dry. In order to ascertain whether the rain had penetrated the outer part of the wall a hole was made in a particularly exposed piece of wall, and it was observed that the rain had not succeeded in penetrating further than $\frac{1}{16}$ in. The $4\frac{1}{2}$ in. cavity should keep the houses at an equitable temperature throughout extremes of heat and of cold, and obviate trouble due to condensation.

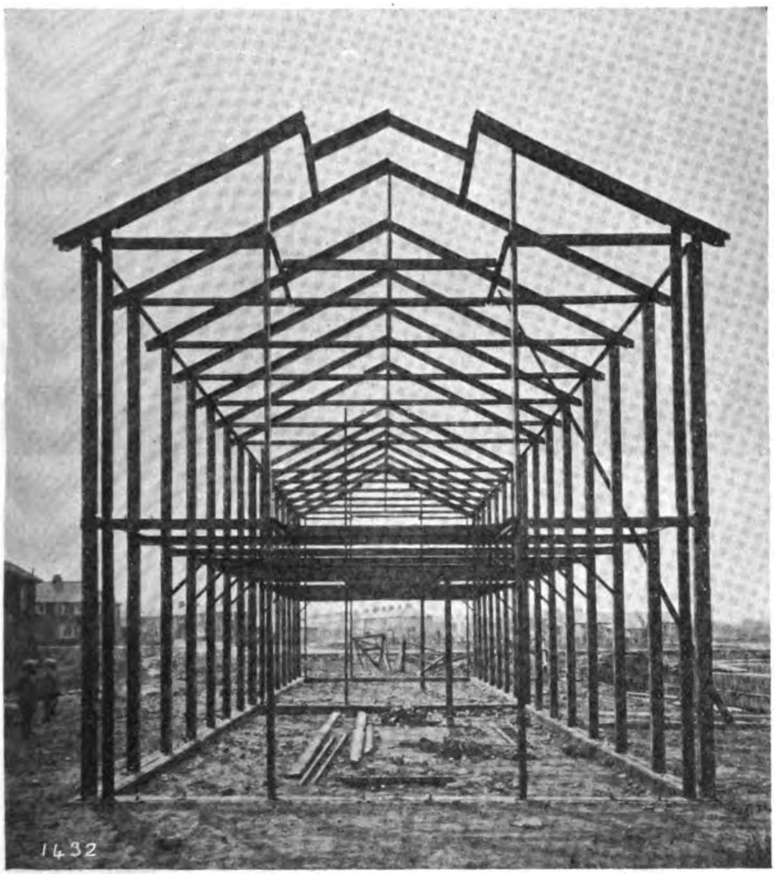
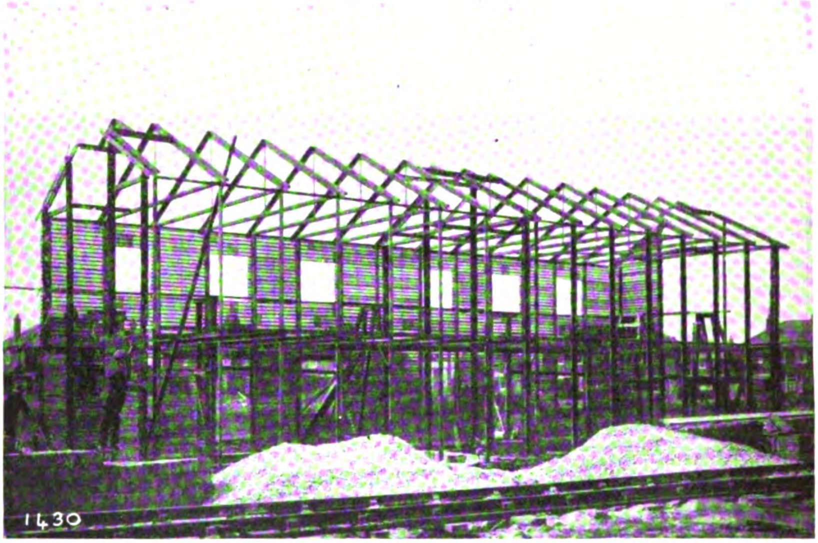
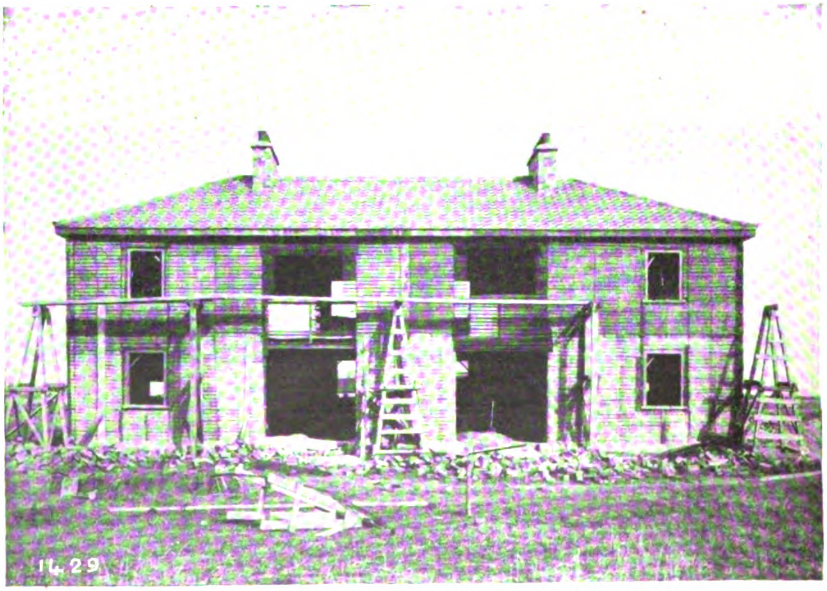


**Fig. 2. Showing Frame-work of the Houses.**
CONCRETE COTTAGE BUILDING.

It will be observed that the method of construction lends itself most admirably to the treatment which has been adopted, and even the most exacting critic would find little to which exception could be taken, the whole conception being most dignified and scholarly, and altogether worthy of the very best early nineteenth century traditions. There is no false construction, no abuse of material as so often occurs when one material endeavours to disguise itself as another. A further great advantage lies in the fact that although the system is standardised, it allows just that freedom in design and treatment, without which the pursuit of architecture ceases, at once, to be an art.

Although this system of construction was originally evolved by Messrs. Dorman, Long & Co. to meet the requirements for housing their own employees, it has nevertheless proved so successful and aroused so much interest that the company has decided to bring its method of construction before the general public, and to organise it on extensive lines. It has already been approved by the





Figs. 3 & 4. Showing the attachment of the Hy-Rib Reinforcement.
CONCRETE COTTAGE BUILDING.

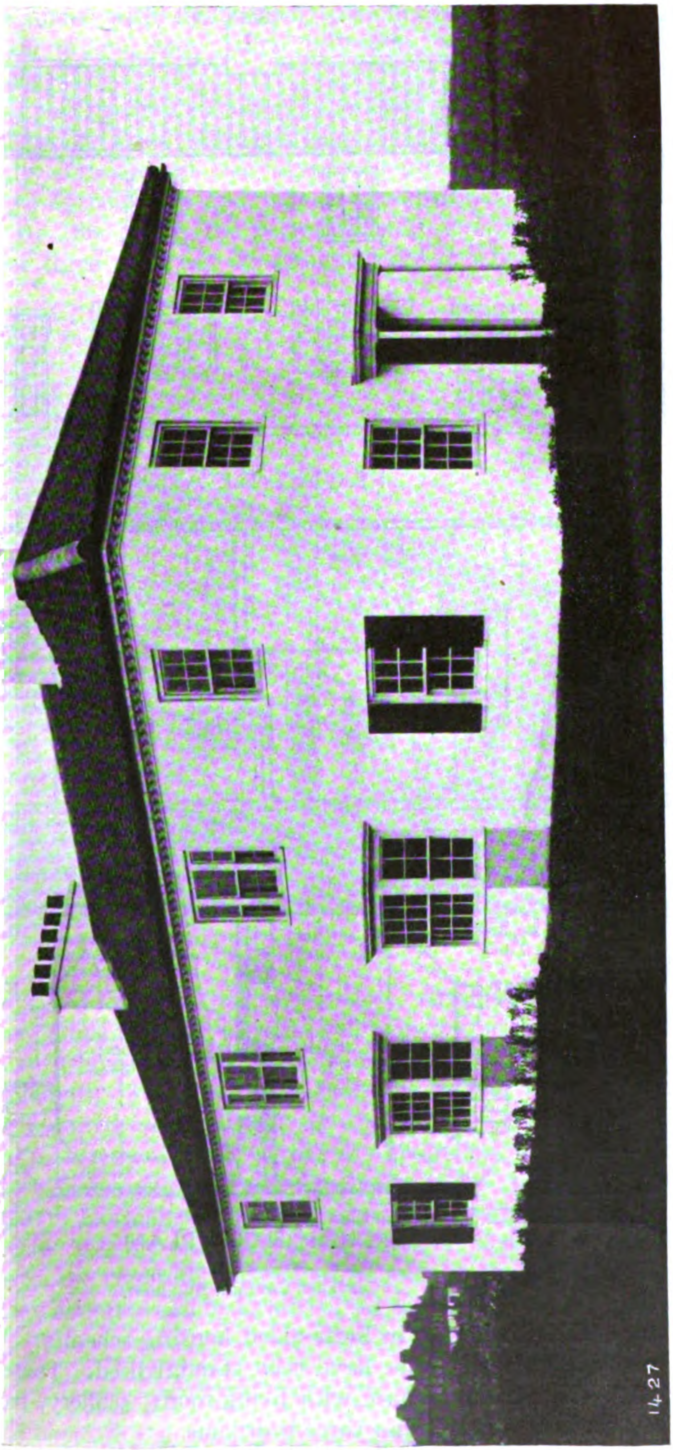
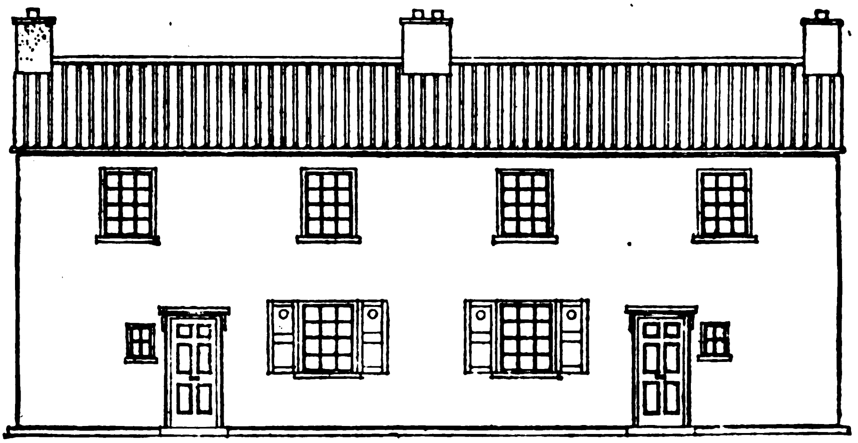
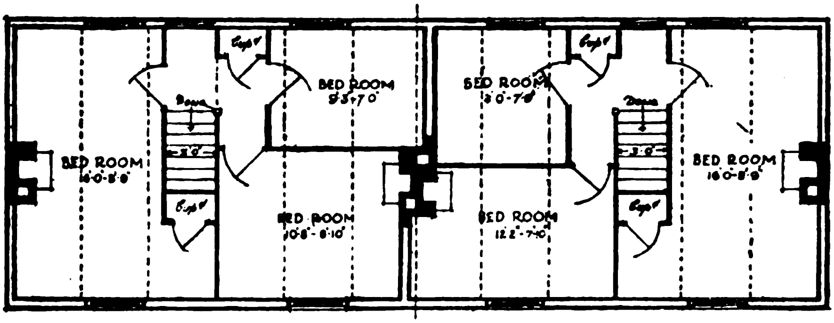


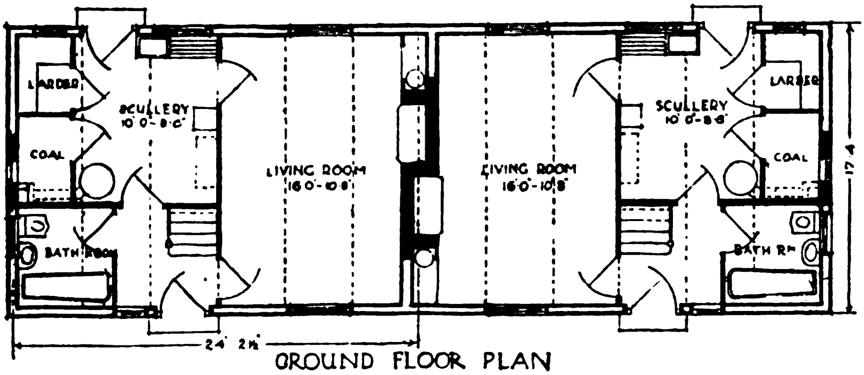
Fig. 5. View of a pair of Houses completed.
CONCRETE COTTAGE BUILDING.



FRONT ELEVATION



FIRST FLOOR PLAN



GROUND FLOOR PLAN

Fig. 6. Plans and Elevation.
CONCRETE COTTAGE BUILDING.

Ministry of Health for use in State-aided housing schemes. With this object in view certain types of houses have been standardised. These include :—

"A."—Non-parlour house with living-room, scullery, bathroom with w.c., coalhouse, larder and three bedrooms.

"B."—Parlour house with living-room, parlour, scullery, coalhouse and larder on the ground floor; three bedrooms, bathroom with w.c., on the first floor.

"B4."—Living-room, parlour, scullery, coalhouse, larder, bathroom with w.c. on the ground floor; four bedrooms on the first floor.

The plan of the standardised "A" type is reproduced in *Fig.* 6. A set of working drawings, specification and bills of quantities have been prepared for these houses. By this means the necessary steel sections, of which each house requires about three tons, can be manufactured in large quantities, thus much time may be saved in the preliminary stages. Arrangements have already been made by the company with various well-known contractors in different parts of the country, who are willing to erect these houses for local authorities or for private individuals. The cost of the houses is estimated at from £650 to £700, and the time required for erection is six weeks.

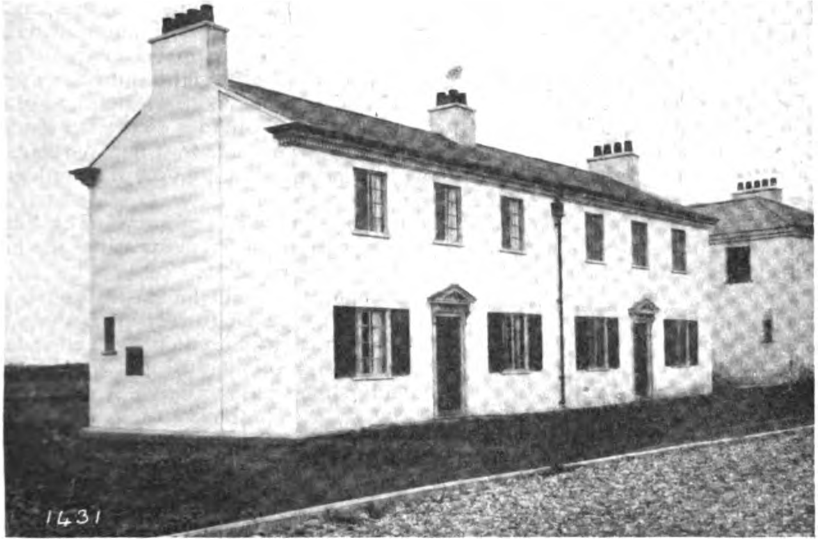
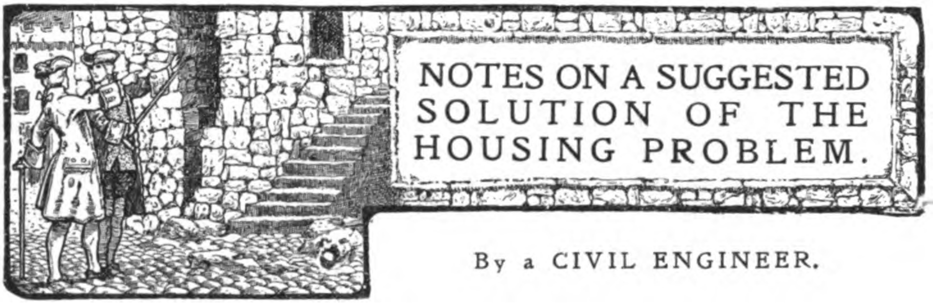


Fig. 7. View of two completed Cottages without bay windows.
CONCRETE COTTAGE BUILDING.

In conclusion, a statement made earlier in this article may be repeated—that for those who would make a comparison between the rival claims of brick and concrete a visit to Dormanstown would provide just what is required; for there can be inspected side by side, completed and occupied houses of the two kinds, and moreover, the concrete houses can be seen at their various stages of erection, so that a fair estimate can be formed of the soundness of the construction.



# NOTES ON A SUGGESTED SOLUTION OF THE HOUSING PROBLEM.

By a CIVIL ENGINEER.

To avoid any misconception, it is desirable at the outset of these notes to make it perfectly clear that the writer has no pretensions nor the necessary artistic ability to pose as an architectural expert. Apart from having had over twenty years' experience in the construction of important railway and dock undertakings, including therein the building (in reinforced concrete and other material) of offices, warehouses, cold stores, police and railway station buildings, etc., he is no better qualified than the average civil engineer to enter into a discussion as to the right and wrong method to employ in solving the problem of the economical and expeditious building of houses to meet the present demand. It is, however, painfully obvious that with tenders for house erection running up to 300 per cent. of pre-war cost, that it is pardonable for even a layman to air his ideas, right or wrong though they may be, in the hope that some way out of the difficulty may be found.

Having thus carefully apologised beforehand, but with no intention of disarming criticism, he will at once endeavour to put forward as clearly as possible the lines on which it is considered a successful solution may be arrived at.

In order to save time and valuable space, which could be easily wasted in discussing buildings of various materials and forms with which everyone is more or less acquainted, it may be as well to state at once that after many months of consideration the conclusion come to is that the efficient modern, economical and quickly-erected house should be built, as regards the outside shell, main internal walls, first-floors and roofs, of cellular blocks of reinforced concrete. The blocks to consist of parallel internal and external reinforced slabs, connected together by thin diagonal concrete members preferably, for many reasons, including that of strength, of a shape thus, in cross section :—

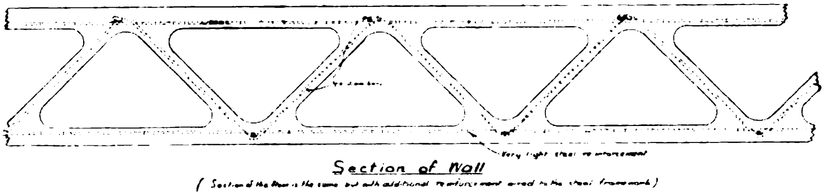

Very light steel reinforcement
Section of Wall
( Section of the floor is the same but with additional reinforcement wired to the steel framework )

FIG. 1.

To make the proposal perfectly clear, step by step, we will consider for a moment any particular part of an outside wall, such as a portion of a gable end. The wall may be, say, 16 in. thick overall. The thickness of the outside slab is, say, 2 in., whilst the inside and diagonal slabs are 1½ in. Any section through the wall at right-angles to the face will thus pass through about 6 in. of material. That is to say that every sq. ft. of walling will be ⅜ths the weight of a solid wall of equal width. It will, however, possess other advantages, besides that of lightness, over a solid brick or concrete wall. Being cored with large triangular cells of air, it will be dry and a non-conductor of heat. Consequently a house built with such walls will be warm in winter and cool in summer. Further, the inner face of the wall will be free from internal condensation. Again, the internal and external slabs, being connected together by reinforced concrete slabs arranged like the diagonal members of a bridge girder of the well-known Warren type, will have a strength far superior to walls made of separate slabs tied together by galvanised clips or other members placed at right-angles to the face of the wall. We will leave the reader to further consider the relative advantages or disadvantages of such a wall compared with a wall of separate slabs or of small man-handled machine-made blocks of un-reinforced concrete.

So far as we have gone, two practical questions at once arise :—

(*a*) How to reinforce such a wall economically.

(*b*) How, in the simplest and cheapest manner, to devise a triangular core that can be concreted in and afterwards removed when required without damaging the newly-set concrete.

It will suffice here to state that both problems have been solved to the great satisfaction of all concerned. In the case of (*a*), by the pyramidal reinforcement extensively used by the Port of London Authority, and now introduced to the public by the Walker-Weston Co., Ltd., of Empire House, 7, Wormwood Street, E.C.2, ; and (*b*), by the discovery of an ingenious and cheap type of a two-handled triangular collapsible core, which, by taking hold of one handle, sets itself, and by taking hold of the other collapses, so to be readily withdrawn. The core is simplicity itself, with no loose parts, wedges, removable screws, or nails, and can be set and unset in a few seconds. Further, such a core requires only to be wiped with an oil rag before depositing the concrete.

Most engineers who have had considerable experience in reinforced concrete work, including the erection of reinforced concrete buildings, know how largely bulk the items for shuttering and the depositing of concrete. After the first lift, to these items have to be added that of scaffolding, raising the material, and other attendant costs. Many engineers have, no doubt, had cases where a partition wall has been designed, say, 4 in. to 6 in. thick of reinforced concrete, which could have been put in at half the cost, and just as efficiently, in other material. Such occasions, with their heavy attendant charges for scaffolding, forms, fixing steelwork and hoisting material, all items out of proportion to the finished measurements, often have been the cause of voluble denunciations of the folly of injudicious and impractical applications of otherwise excellent methods of construction. The outcome of such experience has forced the conviction that it is impossible to cast a house economically *in situ* of solid or hollow wall reinforced concrete construction. The alternative here considered is to divide the house into suitable large-sized blocks, which may conveniently run up to 3 tons in weight. The only restrictions as to weight are the capacity of the cranes and means of transport to the building site, etc. These blocks may be made in the builder's yard, either at his headquarters or at the site under a suitable crane, such as is hereinafter described. Here materials and labour can be centralised as much as possible. Such a procedure would have the advantage of making it possible to let the work out on piecework rates among the steelworkers, form erectors, and concreting gangs. The work at site would then consist as much as possible of mere erection work in a similar manner to the erection of a steel frame building or bridge. By substituting reinforced concrete slabs, as above described, for first-floor and roof, instead of timber and employing steel frame windows and doors, the number of tradesmen at site could be reduced to a minimum.

With varying types of standard houses, built up as much as possible of uniform standard blocks, the yard could in slack times be employed in making stock, so that a house could, if desired, be supplied direct out of stock and erected in a phenomenally short time.

The practical man will at once be inclined to damn such a scheme by asking how it is possible with the means and cranes at the disposal of the average builder to command the site of a house or row of houses in such a way as to be able, economically and efficiently, not only to unload, but to place in position such blocks. It is at once admitted that on the answer to such a question depends the success or failure of any proposal to erect buildings as herein proposed.

The solution of the problem is simplicity itself, and consists in the application of a new method of handling heavy weights over wide spans now being developed on the new works of the Port of London Authority. It may be taken that a crane commanding a long row of cottages, and able to pick up and deposit loads of 3 tons in an oblong area of indefinite length by a breadth of 50 ft. to 60 ft., with a height of deposit of 30 ft. above ground level, will be sufficient for the purpose required in practically all of the new housing schemes. The Port of London Authority have erected an electrically-operated crane of this type to command an area 1,200 ft. long by 140 ft. wide, and to deposit pre-moulded concrete members of a maximum weight of 3½ tons in a building 45 ft. high. The cost of such a crane is remarkably small compared with cranes of pre-war types. The illustration (*Fig.* 2) shows the crane in question transporting a pre-moulded girder weighing 3 tons 9 cwts. to its position in the building. A point of interest in the photograph is the concrete road in the foreground, reinforced with the Walker-Weston mesh here recommended for the construction of houses. The road is unique in the sense that no objectionable expansion-joints have been provided, neither has experience shown them to be necessary. Further, this road was laid down with a similar type of crane to the above, only on a much smaller scale.

The above remarks may seem irrelevant to the point at issue, but it must be understood that the proposed housing solution has progressed steadily forward from such early beginnings, which, themselves originating in theory, have proved themselves conclusively economical and successful in practice.

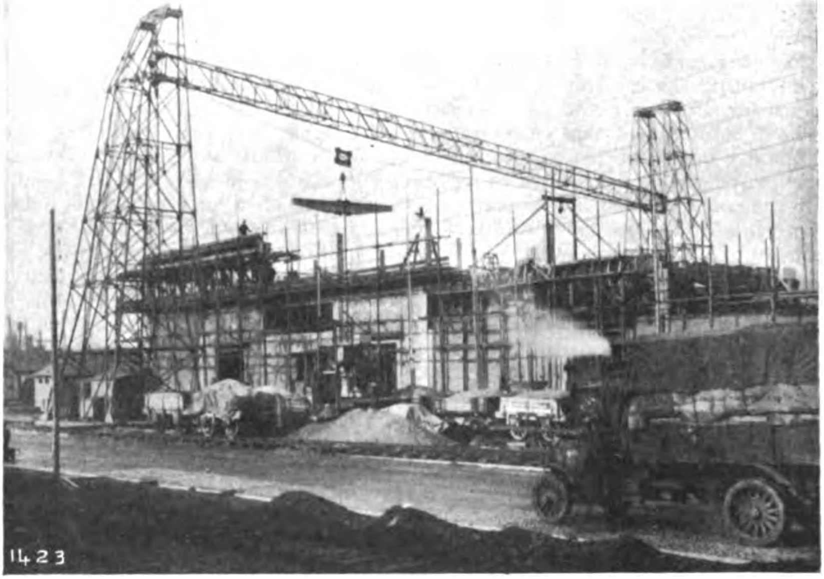


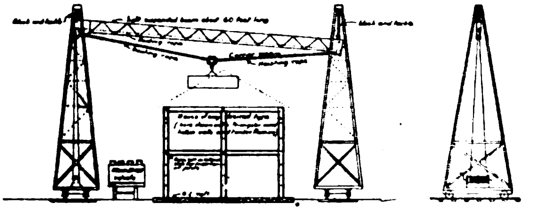
Fig. 2. View showing Crane transporting a Pre-Moulded Girder into position.

Such a type of crane, electrically-driven, would probably be out of place for erecting cottages, and a smaller and cheaper crane, either hand, steam or oil-driven, is suggested for this purpose.

The principle of the electric crane above referred to consists in the employment of a light overhead-suspended girder, either of steel or timber. This girder is so constructed as to be little more than sufficient to carry its own weight when suspended at its two ends from convenient supports. A suitable girder may be about 60 ft. long by 3 ft. deep in side elevation, whilst in plan it is 3 ft. wide at the centre, tapering to 9 in. to 1 ft. wide at each end. From the underside of the girder is suspended a wire rope. Each end of the wire rope is attached to the underside of one end of the girder. By a suitable tautening device the wire rope can be pulled in or let out to give any desired sag. On this wire rope runs a wheeled carriage. Provision is made by means of a hauling rope to haul this carriage in one direction. Fitted in the bottom of the carriage are the upper sheaves of a block-and-tackle arrangement for hoisting the load. The bottom sheaves of this tackle are fixed in a block provided with a hook or eye to which the load to be lifted is attached. The hoisting-rope passes through these sheaves, and is led off from the carriage in an opposite direction to the hauling-rope. Convenient pulleys are inserted in the ends of the overhead girder to guide the hauling and hoisting ropes to winches conveniently placed in the base of one of the supports. As before stated, the hauling-rope is provided to haul the carriage in one direction only. To move the carriage in the other direction advantage is taken of the horizontal pull of the hoisting-rope and the inclination of the sag in the rope towards the centre of the span. Further, the overhead boom itself can be inclined so as to make a downhill pull all the way in one direction, viz., along the lead of the hoisting-rope, and an uphill pull in the direction of the hauling-rope from the carriage to the hauling rope sheave at the end of the girder.

Anyone conversant with the complications of fixed cableways with towers at equal altitudes will readily appreciate that in the arrangement above described the simple device of inclining the girder dispenses with the necessity of employing more than one hauling-rope; and further, with such small spans as required for our present purpose, the provision of button-ropes and hangers to take up the sag of the hoisting-rope when unloaded is an unnecessary refinement.

Having described roughly the essential features of the structure, viz., the suspended overhead strut and the wire rope cable attached to the underside thereof, let us consider wherein lie its simplicity and its advantage over any other type of crane. The overhead girder tends to sag in the centre, due to its own weight, with a consequent compression in the top flange and tension in the lower flange. The pulls exerted on the overhead girder at the ends of the loaded cableway act so as to try to buckle the girder upwards at the centre, tending to extend the top flange and compress the lower flange. Such pairs of stresses serve to neutralize one another, with the result that the overhead girder acts merely as a strut to keep the ends of the rope from being pulled together. It will be easily understood that the overhead girder, instead of being weakened by the suspension of loads from the carrier, may be actually strengthened at such times. This neutralising of stresses means that a light overhead girder can be employed suitably suspended from two moveable supports, one on either side of the building or row of houses. The two supports can be light towers composed of timber or steel tubes, etc., erected on wheeled carriages; alternatively, they can be structures of the jib type of crane, mounted on bogies. In the latter case the jibs will always be end-on, and not cross-carriage to the wheeled bogies, the top ends of the jibs plumbing the bogies. As there is no cantilever action, with consequent necessity for counterbalance weights, the whole weight of the structure, and consequently the cost, is at a minimum. Further, as the efficiency or the ratio of :—



Elevation of Crane

End Elevation

FIG. 3.

$$\frac{\text{Weight to be transported}}{\text{Total weight put in motion}} \times 100$$

is at a maximum, and perhaps twenty to forty times as great as in the case of slewing cantilever cranes with heavy balance weights, it follows that the power required to work the crane is at a minimum.

Such cranes as above described are the subject of a patent, and can be supplied at a low cost, and can be made so as to be easily transportable. They can be designed either to work by hand, steam, petrol, or electric power.

As the overhead girder is suspended by means of block-and-tackle at each end, there is no tendency to jamb or overturn if one bogey gets slightly ahead of the other. By a very simple power or hand-worked contrivance the two bogies can be made to travel backwards or forwards at the same rate, and thus keep the overhead girder square across the line of building.

The diagrammatic sketch (*Fig.* 3) will, perhaps, more clearly indicate the type of crane above described :—

The drums of the two winches for the hauling-rope and hoisting-rope are of the same diameter. They are so arranged that the hoisting drum can be operated while the hauling-rope drum is on brake. Alternatively, by means of a clutch, both drums can be revolved together, so that whilst the hoisting-drum pulls in, the hauling drum pays out, or *vice versa*, and so cause the load to be traversed in either direction.

It will be noted that the method of working is straight-line traverse, as distinct from slewing cranes of the Scotch derrick or travelling loco crane type, which may be classed as circular traverse machines.

This is advantageous in the following respect. The operator, being usually situated near the ground level, is at times inconveniently placed for seeing the site of the deposition of the load. This difficulty is obviated by a simple type of periscope, which not only gives him a clear view of the whole of his field of operations, but also at once indicates to him if the opposite support for the overhead strut is in an advanced or retarded position with reference to the bogie carrying the operating winches. Such a device has no particular novelty in it, as mirrors are often used on slewing cranes for the same purpose.

No apologies are offered for the somewhat elaborate description of a suitable crane for handling the component blocks in the erection of the houses built on the proposed system, as it will be recognised that upon such an appliance depends entirely the feasibility of economical construction of such houses. Not only is this type of crane indispensable for the above purpose, but cranes of a similar type with larger or shorter spans may be considered indispensable in the block-making yard. In the latter case the height of the structure will be only sufficient for the purpose required ; and as it will be necessary to delay work as little as possible for inclement weather conditions, protection from sun and rain can be provided by using the overhead strut as a ridge for a tent-like structure under which the men can work in cases where the builder's yard is situated temporarily on the site of the proposed building estate. Where the builder's yard is of a more permanent character, the same may be advantageously covered over with a low roof of the timber Belfast type.

It will, no doubt, be recognised as a common experience that once one has convinced himself of what he considers as the right, simple and direct line of action in the solution of a problem, all matters of detail and design seem to solve themselves, and, in a manner of speaking, crowd themselves forward in their haste, to show how naturally they will work into the completed scheme. This peculiarity is very apparent in the case under consideration, not only as regards the jointing and bonding of the blocks and other details, but also in the substitution of reinforced concrete members for timber in the floors and roofs. A particular case in point is the objection that might be raised of building houses of hollow concrete walls 1 ft. 4 in. thick, instead of jerry-built brick walls 9 in thick. Consider the valuable ground space wasted in reverting back to the practices of our forefathers who took a pride in building walls of even greater thickness for similar purposes.

It has to be admitted at once that thick main walls in the ground storey will cover, as far as available floor space is concerned, more area than thin walls. This only applies to the main walls, as the partition walls can be erected on any system preferred, either thick or thin, and disposed as found convenient, according to requirements. But with this system what you lose on the swings you gain on the roundabouts. In other words, the area lost in the ground-floor can be gained in the first-floor, with resultant economy in material, due to taking advantage of the stresses in overhanging girders, and also with improved æsthetic appearance in the finished structure.

To explain how it is possible to gain additional floor area in the upper floors to make up for the loss in the ground-floor due to increased thickness of walls, it is to be remembered that the proposal is, where desired, to use reinforced concrete floor slabs for the first-floor and roof, instead of timber. In such a case, suppose these floor slabs to overhang the ground-floor walls by 2 or 3 ft., and the walls of the first storey to be carried upwards with such overhang, thus :—

It is obvious that one result aimed at is accomplished ; but the question arises at once as to where the promised economy has taken place. To an engineer versed in stresses it is self-evident that by so loading a girder structure such as the floor or roof

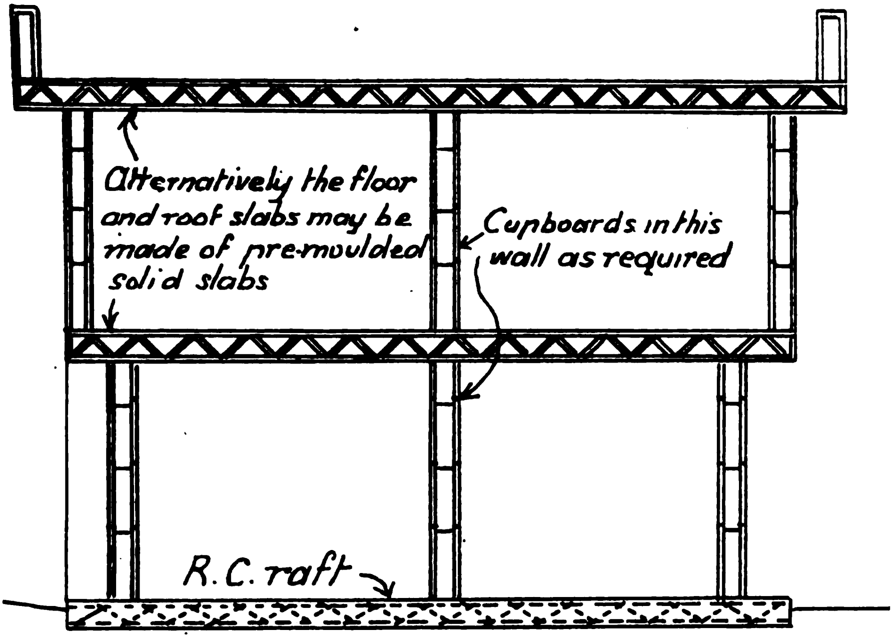

Alternatively the floor and roof slabs may be made of pre-moulded solid slabs
Cupboards in this wall as required
R.C. raft

Fig. 4.

the weight of the walls are arranged so as to balance the dead load of the girder in the centre of the span, and tend to put the upper part of the floor in tension and the bottom in compression. Further, such an arrangement tends to reduce the shearing stresses. Any stresses due to live load coming on the floor tends also to be neutralized by the overhanging weight of the walls. If the stresses be neutralized in the middle of the span, it follows that economy in steel reinforcement ensues per sq. ft. of floor area over a similar structure where the first floor walls are built directly above the ground-floor walls.

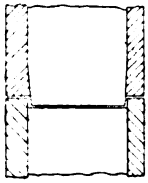
So much for the economical part of the arrangement. For the other it is timidly submitted that the overhanging of the floor and roof as shown will serve both a useful purpose in keeping the walls dry, and will, also, by the horizontal shadows in the elevation, give a more pleasing appearance than that given by walls going plumb up without such offsets. Further, bay windows may, if desired, be introduced in the ground floor, and, perhaps, in the first-floor, with further improved appearance.

There is one other point it is desired to touch upon as regards appearance, namely, the question of the surface treatment of the exposed face of the building. It is considered that no one will contend that any beauty appertains to the cement skin face left on the outside of the concrete when the forms are removed, and there are many advocates for sand-blasting or brushing this off whilst the concrete is still green. It is obvious that in a building where the concrete is cast *in situ* many difficulties lie in the way of the successful and economical carrying out of this desideratum. Where, however, the blocks are pre-moulded on the ground and the forms removed whilst the concrete is still green, this is an easy matter of accomplishment, and will show up to great advantage in the finished building.

Before finishing off these notes and putting them forward for criticism, there remain to be touched upon one or two points, including the question of joints, both horizontal and vertical. As before stated, each detail as it arises seems to solve itself. In the case of the horizontal joints in the walls, a satisfactory mortice and tenon-joint is provided, as shown in *Fig* 5.

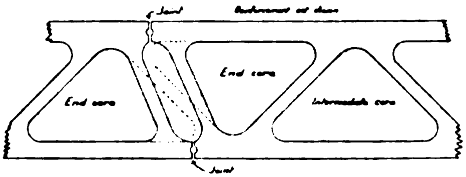
It will be seen that the diagonal webs mortice and tenon into one another, and that the top of each slab may be thickened out if desired, both for appearance and convenience in erection. The vertical joints are also perfectly simple. It is, of course, to be desired that the triangular vertical cells shall, for many reasons, be plumb throughout the height of the walls. It is therefore necessary to detail such joints in such a way that this object may be made easy of attainment.

The sketch (*Fig.* 6) below is sufficient to indicate the lines of procedure :—
The abutting of two walls at a square corner admits also of a simple and efficient construction.



*Horizontal Joint*

FIG. 5.



*Vertical Joint*

FIG. 6.

As regards window and door openings, these, if so desired, will conveniently be made splayed to follow the diagonal web and be in appearance similar to windows and doors in old-fashioned houses, the splay being arranged so as to give a wider internal aperture than external.

With reference to the floor and roof, it is perhaps necessary to add a few words to explain the method to be employed. It is proposed to make them in strips to extend if need be, in one length from back to front of the building. Each strip can be conveniently 30 ft. by 2 ft. by 1 ft. 4 in. or 1 ft. 6 in. deep, and consist of itself of a Warren girder-like concrete member, easily and cheaply made and suitably reinforced. The strips will be planted on the wall, side by side, and suitably jointed as before described. Such a strip has been built as long as 35 ft. by 13 in. by 13 in. and utilised as a telegraph pole with great success. The question of additional covering to the floor in the shape of some softer material than concrete or otherwise can be left for individual decision.

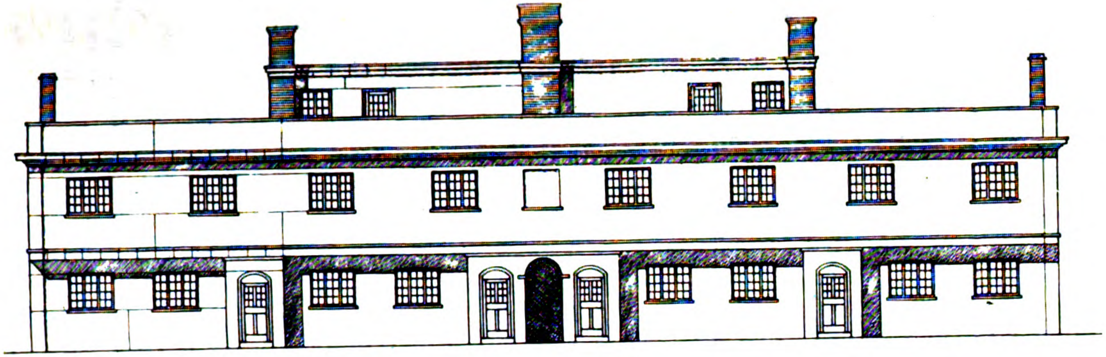
Again, as regards the aggregate to be used. It is a simple matter to make the exterior slab of gravel concrete and the interior slab of coke breeze concrete or other mixture. In this case facilities will be given in the interior of the building for the driving of nails into the walls. The writer personally considers the driving of nails into coke breeze concrete an unsatisfactory procedure, and would prefer the very simple expedient of leaving holes as required in the form supporting the inner slab and inserting in these holes little taper pegs. These pegs could be withdrawn after the concrete had partly set, leaving little holes in the vertical face of the blocks which could be plugged with wood for holding nails driven into them, or the holes could be plastered up as required. Other expedients in a hollow wall of the type in question are obvious.

Cupboards, as desired, can be inserted in the inner middle wall of the building at chosen spots by substituting a single-slab walling for the two-slab cellular construction.

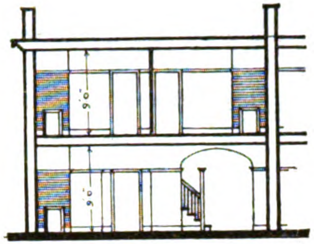
Any other points requiring consideration, such as flues, doors, windows, drains, down-pipes, &c., all offer easy solution, and can be left to the imagination.

In leaving these suggestions for the reader's careful consideration, it should be added that there is very little that is really novel in the foregoing proposals. The idea is to adopt to house building practices which have been, and are, prevalent in every well-managed engineering concern. A firm making bridges, lock-gates, steel buildings, or such-like invariably sends to the site the component parts of the structure in as large units as can conveniently be handled, so as to reduce to a minimum the work at site. Such units often reach the weights of 15 to 20 tons. To be conservative, we suggest a limit of 3 tons to the unit for house building. It should require little effort to calculate roughly the approximate time to run up a row of houses with such sized blocks already previously matured.

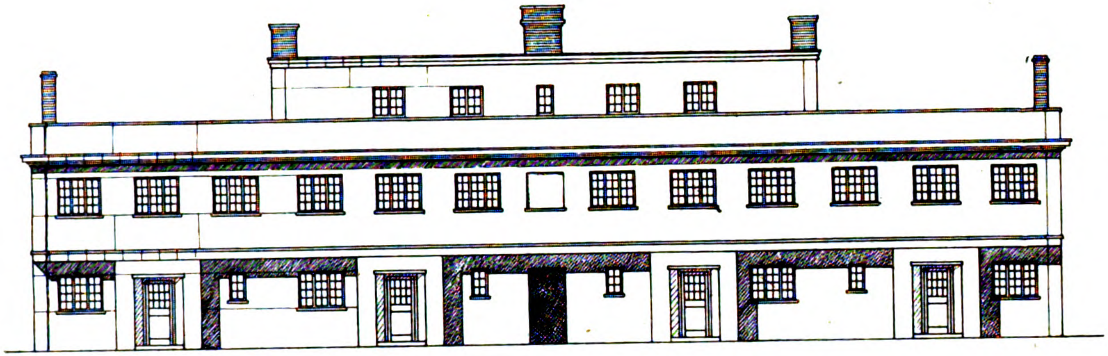
## A BLOCK OF FOUR CONCRETE COTTAGES.



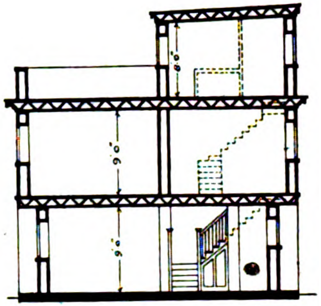
FRONT ELEVATION



SECTION C-D.



BACK ELEVATION



SECTION A-B.

Subsequent to finishing the above, the writer considered it highly desirable to collaborate with an architect well-known for his design of artistic houses, and approached Mr. Elson Hardy, Lic. R.I.B.A., whose work is well-known to readers of architectural papers. He has entered enthusiastically into the above proposals and supplied the lacking element of architectural ability and experience. The result has been a block of four workmen's dwellings, as shown in *Figs.* 7 and 8, which serve excellently to illustrate the writer's preconceived ideas on the subject. Each house has a large living-room, a commodious scullery, three good bedrooms, a bathroom and w.c. combined, inside accommodation for a perambulator and bicycle, and is also provided with a cool larder, which latter is surrounded by non-conducting walls of cellular reinforced concrete.

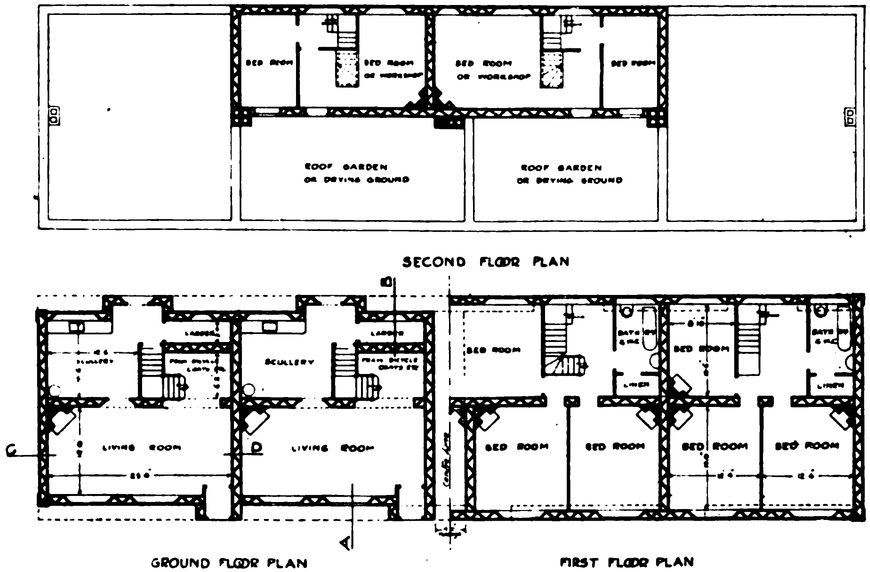


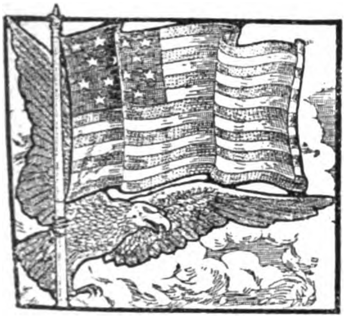
FIG. 8.

The drawing is intended merely to illustrate the system, which is by no means confined to houses of this type. It is equally applicable to the more conventional design of house with timber floors and ridged roofs.

It will be noted that in the accompanying design the usual narrow and often dingy passage or hall on the ground-floor has been omitted, the entrance being direct from the lobby into the large and commodious living-room. Should more bedroom accommodation be required, it is a simple matter, and at comparatively small extra cost, to utilise the flat roof by adding thereon another bedroom, together with a workshop or summerhouse, whilst still leaving room for a small roof garden or alternative drying-ground. The design as drawn shows this latter arrangement, the roof being reached by a second flight of stairs from the first-floor landing.

This method of construction would be particularly adapted to the building of economical two-storied flats, with accommodation in each flat for living-room, scullery, etc., and two or more bedrooms. In this case the ground floor tenant would have sole use of the garden or yard for a drying-ground, whilst the occupant of the first floor would utilise the flat roof for such purpose.

The writer in conclusion takes this opportunity of again thanking Mr. Elson Hardy for his collaboration, and sincerely hopes that their joint efforts may pave the way to the economical erection of thousands of improved houses for the rearing of an A1 population.



# THE PLACE OF CONCRETE IN THE COMING ERA, ON THE NORTH AMERICAN CONTINENT.

By EDWIN TOMLIN, Victoria, B.C.

(*Concluded.*)

*In the first part of this article, which appeared in our January issue, the author drew attention to the increasing use of concrete in the United States during the last twenty years, and gave examples of its use for large engineering structures, grain elevators, bridges, aqueducts, etc. He then went on to the question of roads, and pointed to the extraordinary development of the concrete road all over the American continent.—ED.*

## HARBOUR WORKS.

THIS survey of the modern uses of concrete would be sadly incomplete without some mention of the extensive use to which it has been put in recent years on our sea-coasts and harbours. Readers will be interested to learn that the Bureau of Standards, Washington, D.C., appointed two of their members in 1917 to make a thorough investigation of all the concrete structures in sea water on the Canadian and American Atlantic and Pacific Coasts, with a view to ascertaining the effects of salt water on concrete. One hundred and forty-six concrete structures, of great importance on the coasts referred to, were visited, ranging from New Brunswick on the Canadian Atlantic Coast in the north to the Gulf of Mexico on the American Atlantic Coast to the south, and similarly from Victoria, British Columbia, on the Canadian Pacific Coast in the north to San Diego, California, on the American Pacific Coast to the south.

The result of these investigations* demonstrated beyond cavil that with proper materials and efficient methods of construction, concrete will withstand the ravages of the sea, wind, and wave stress indefinitely. The old type of marine construction on both the Atlantic and Pacific Coasts was the use of fir piles with a backfill behind them. This is gradually being replaced by a variety of types of concrete construction, among which could be mentioned reinforced concrete piles with a concrete or wood decking, concrete sheet pile with a solid backfill behind, concrete pontoons sunk in place and filled with gravel, and concrete pedestal type with wooden superstructure above. There are many types of concrete wharves being constructed on both the Atlantic and the Pacific Coasts.

## ITS USE IN LARGE HYDRO-ELECTRIC SCHEMES.

All over the American Continent concrete has been very successfully used in the formation of power dams, to harness the rivers for generating electrical energy. Very notable examples might be cited of the enormous dam crossing the Mississippi River, as well as those at Niagara Falls. This form of construction is increasing constantly year by year—as it is realised how economically electrical energy can be generated by water power.

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* See CONCRETE AND CONSTRUCTIONAL ENGINEERING, Vol. XIII., pp. 99, 147, 410, 473, 525 and 597.

### PUBLIC BUILDINGS.

In the matter of public buildings, concrete has had a veritable triumph during the last ten years. For use in the building of hotels, apartment houses, hospitals, universities, offices, and other public buildings, reinforced concrete has taken a place of leading importance among all other materials. Similarly, in the construction of railway terminals, it is unsurpassed for its strength, adaptability, and architectural beauty. One could mention many hundreds of examples where concrete has been used for hotel buildings and railway terminals, but perhaps no two finer illustrations could be quoted than the Vanderbilt Hotel in New York, and the famous Pennsylvania railroad terminal in the same city. One cannot look at these two structures without being impressed with the superb position which concrete possesses to-day as a material of lasting permanence.

### DRY DOCKS.

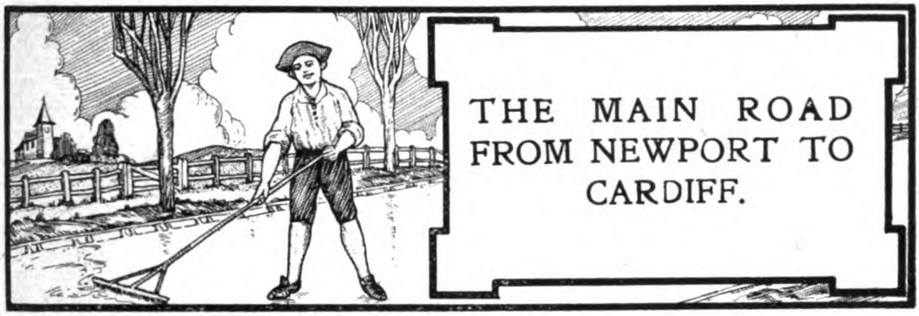
Reference must also be made to concrete for use in the building of dry docks. A large undertaking has just been completed at Pearl Harbour on the Island of Oahu, belonging to the Hawaiian Group. At Pearl Harbour the Secretary of the American Navy has recently officially opened the Government dry dock, which is one of the largest in the world. This is of reinforced concrete, and has been under construction for the past four years. At Esquimalt, on Vancouver Island, the Canadian Government have decided to build a dry dock of reinforced concrete surpassing in size the one just referred to. It will be 1,100 ft. long and 115 ft. wide, capable of holding the largest ships afloat. Mention could be made of numerous instances where this material has been used for this class of work, but readers will be interested in the examples quoted.

### ITS VARIOUS MINOR USES.

We have not yet exhausted by any means the important uses to which concrete is being put at the present time. It is not incorrect to say that their number is legion. On the modern farm we find concrete silos, piggeries, cowbarns, stables, fence posts, side walks, drain tile, water tanks, etc. In the factory we find concrete foundations, floors, roof supports, roofs, bins, offices, yards, and driveways. Around our homes we see concrete foundations, walls, steps, sidewalks, basement floors, laundry tubs, and what not. In our cities are endless miles of concrete side walks, sewers, and surface drains, not to speak of numerous concrete manholes, retaining walls, and foundations. It might truly be said that the ramifications of concrete are getting beyond the ability of any one man to catalogue them at a sitting, and yet as a building material it is still in its infancy.

### CONCLUSION.

As a concluding word, it is true to remark that in these days of propaganda one usually finds an excuse or an apology when it is introduced to the public. Concrete does not need any such introduction. It renders 100 per cent. value for money paid. Its trade-mark and inalienable birthright is " Permanence," and as such we commend these lines to the reading public who are interested in building construction.



# THE MAIN ROAD FROM NEWPORT TO CARDIFF.

*An interesting trial length of concrete road has just been laid on the main road between Newport and Cardiff. Below we give some short particulars of this road as furnished by Mr. Ivor F. Shellard, Assoc.M.Inst.C.E., Chief Engineering Assistant to the Borough and Water Engineer at Newport. Our information is taken from an article which recently appeared in "The Surveyor." We are also indebted to Mr. Shellard for our illustration. —ED.*

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THE main Newport to Cardiff road is probably one of the most heavily trafficked roads in South Wales. This road, although specially treated, has never satisfactorily withstood the exceptional traffic, the poor subsoil being to some extent the reason ; so that it was thought that, all things considered, the position would give an excellent test of the possibilities of a reinforced concrete road.

Owing to the absolute necessity of keeping the road open to traffic, the length was treated in two portions. The width of the road between kerb lines was from 24 ft. to 26 ft., and as the width of the reinforcement was 7 ft., a 14-ft. width for the length of 300 ft. was dealt with first, thus leaving the remaining width open to the traffic.

The reinforcement used was B.R.C. Fabric, Ref. No. 9, and, working in conjunction with the representatives of this firm, the following details of construction were arranged :—

The thickness generally to be 6 in., laid in one course, with the reinforcement placed about 2 in. above the bottom of the concrete. The concrete to consist of one and a-half of 2-in. local limestone, one and a-half of 1-in. stone, one and a-half of coarse sand to one part of cement. Transverse joints not to be provided, but a longitudinal joint to be formed along the whole length between the two portions of the road as laid. A strip of thin tarred felting to be placed against the finished portion as the work of laying the remaining portion proceeded ; thus the two lengths would be absolutely independent of each other. When the concrete butted the kerb a clay joint of about ¼ in. to be made on both sides. At the end of the day's work an additional strip of reinforcement 3 ft. wide to be built into the last portion of the day's work about 2 in. below the top of the concrete, leaving 18 in. of the 3-ft. width projecting, in order to help the bond with the next day's work. When completed the road to be allowed to harden for at least three weeks before opening to traffic, the surface being treated with tar and grit at the end of this period.

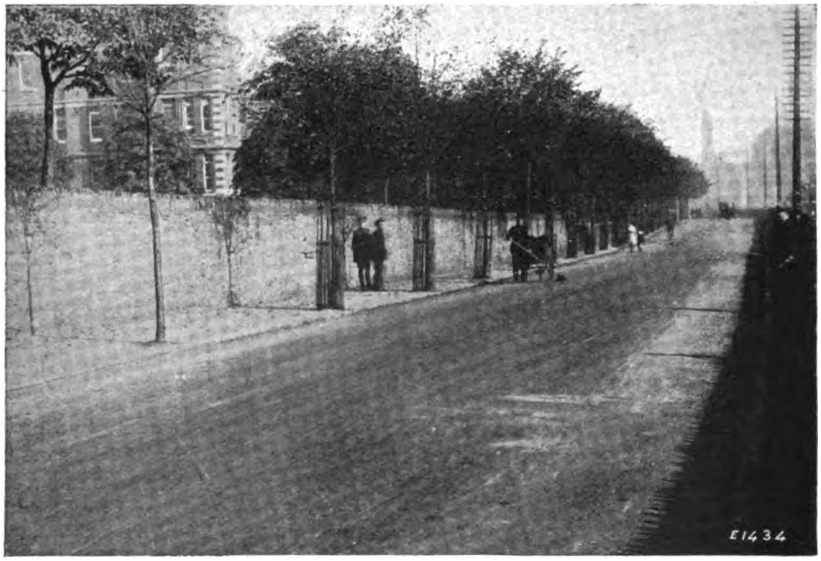
Owing to there being a difference of level of 6 in. between the kerb lines of the road, it was not possible to obtain an ideal crossfall, and the highest point or crown was situated at the apex of the 14-ft. width. This allowed a crossfall of approximately 2 in. in the remaining 7-ft. width.

## PRELIMINARY WORK.

Before proceeding with the work, experimental blocks of concrete were made and placed under test in order to make sure that the material to be used would give the desired consistency with freedom of voids ; also samples of cement were taken and tested.

After the work of scarifying and removing the old macadam surface had been carried out to the required depth, the foundation, which was not any too good, was well rolled by a 12-ton roller, and made up in a few sunken places with hard, dry filling. Before proceeding with the concrete work, the margins adjoining the existing road were laid with two courses of granite setts in cement.

In order to obtain the required contour, wooden floaters or templates were made 2 in. thick (thinner ones were tried and not found suitable), 6 in. wide, and of a length sufficient to reach across the portion to be laid, the required contour being cut out in the length. As a guide for the floater ¾-in. boards were placed at the required level along the kerb-line and also at the other extremity of the work, and as it would be necessary to remove these boards at the finish of the work, to facilitate removal they were made in 4-ft. lengths.



THE MAIN ROAD FROM NEWPORT TO CARDIFF.

### LAYING OF CONCRETE.

The work of laying the concrete was carried out exactly as specified, and undoubtedly the greatest difficulty was experienced in carrying out economically this part of the work, owing to the somewhat confined space caused through the necessity of keeping the one part of the road free for traffic.

It was absolutely essential that the bottom 2-in. thickness of concrete upon which the reinforcement was laid should not in any way set before the placing on of the reinforcement, followed by the top 4-in. thickness, otherwise the idea of the homogeneous mass would be lost. To obtain this result considerable time was lost in having continually to manipulate the roll of reinforcement and staging upon which the concrete was mixed, which would not have been the case if a free space had been available for mixing instead of having immediately to precede the work, as was the case.

Before spreading the concrete the foundation was saturated with water in order that none should be drawn away from the concrete when placed into position. While being spread the concrete was tamped down by shovel and rammer, and no attempt was made to grade the material, there being the same proportion of large stone at the top as in the bottom of the concrete.

The surface was obtained by means of the floater before-mentioned, a man at each end gripping the handles attached thereto and tamping along the fresh surface until the ends of the floater rested upon the levelled boards, the concrete thus being finished off to the shape of the template cut in the floater. No other treatment was given to the surface of the concrete, the results obtained being considered very satisfactory.

### MIXING.

As regards the mixing of the concrete, great care was taken that the proportions as specified were adhered to with each banker. A gauge-box ⅓ cu. yd. capacity, with strips placed at half depth, allowed the easy gauging of the 1½ large stone, 1½ of 1-in. stone, 1½ of sand, and the 1 part of cement; the whole was mixed by hand, and only sufficient water added to make the mass into just a plastic state. The amount of water is of great importance with this class of work. On no account should the concrete be sloppy; 75 to 80 per cent. of the cement volume is the recommended quantity to be used.

Each portion of the road when completed was allowed to stand at least three weeks before opening to traffic, and during that time the surface was kept covered with fine sand to a depth of 1 in., and continually kept damp with water. Immediately before opening to traffic the surface was brushed clean and allowed to dry thoroughly before covering with tar brushed in by hand and gritted.

Before covering with tar the concrete surface was carefully inspected, and gave the appearance of excellent condition.

As with all new constructions, it is the practical test which counts. This new concrete road has now been open for close upon three months, and has during that time, especially owing to the railway strike, carried most excessive traffic. Two days after the opening of the first portion laid a very heavy traction engine with three loaded trailer wagons, the whole weighing at least 50 tons, passed over it; also, six days after, a huge piece of machinery which had to pass through the town during the night, owing to its size, the weight upon one axle being close upon 20 tons, was drawn over the new length of concrete road. Coupled with this, the continuous heavy and fully loaded motor-lorry traffic which used this road during the railway strike, it being the main trunk road into South Wales, has undoubtedly proved that this concrete road is well able to carry any traffic which is likely to be brought upon it. Time alone will tell what effect adverse weather conditons will have, but up to the present the surface has the same appearance as when first opened, and there appears to be no reason why this should not be the case in twelve months' time.

### COST.

As regards the cost, this has been rather high, but if good results are going to be obtained the saving in upkeep and renewal may very well counterbalance this; also it must not be forgotten that with any paved surface it is necessary to lay a concrete foundation if heavy traffic is to be expected.

The cost of labour and also the amount of material used are given, as it may be some guide to those contemplating this mode of construction.

Cost of removing existing macadam roadway and preparing for concrete. Length, 300 ft.; average width, 24 ft., equals 800 sq. yds.; average depth, 6 in.:—

| | £ | s. | d. |
|---|---|---|---|
| Labour .. .. .. .. .. .. .. | 56 | 10 | 9 |
| Horse hire .. .. .. .. .. .. | 35 | 8 | 5 |
| Roller (scarifying and rolling) .. .. .. .. | 8 | 15 | 0 |
| Watching and lighting .. .. .. .. .. | 13 | 10 | 0 |
| Supervision (say) .. .. .. .. .. | 5 | 0 | 0 |
| Total .. .. .. .. | £119 | 4 | 2 |

This works out at 3s. per sup. yd. for preparing only.

There were 206 loads of useful material removed from the road and 300 ft. run of 12 in. by 5 in. stone channelling—for which a credit of £71 10s. is placed to the job.

Cost of reinforced concrete work :—

| | £ | s. | d. |
|---|---|---|---|
| Horse hire | 47 | 8 | 0 |
| Labour | 154 | 2 | 3 |
| Watching, lighting and fuel | 34 | 5 | 0 |
| 2-in. stone (73 tons 10 cwt. 3 qr. at 12s.) | 44 | 2 | 4 |
| 1-in. stone (69 tons 2 cwt. 2 qr. at 12s. 3d.) | 41 | 9 | 6 |
| Gravel and sand (86 tons 5 cwt. 1 qr. at 12s.) | 51 | 15 | 2 |
| Cement (42 tons 14 cwt. 1 qr. at 74s. 9d.) | 159 | 11 | 0 |
| Use of timber for staging, etc. | 25 | 3 | 6 |
| B.R.C. fabric | 108 | 8 | 9 |
| Incidentals | 1 | 16 | 0 |
| Tar | 2 | 2 | 4 |
| Supervision (say) | 5 | 0 | 0 |
| Total | £675 | 3 | 10 |

For the 800 sq. yds. 6 in. thick laid this gives a cost per sup. yd. of nearly 16s. 11d.

Taking the inclusive cost of the whole work and giving credit for the salvaged materials :—

| | £ | s. | d. |
|---|---|---|---|
| Cost of preparation | 119 | 4 | 2 |
| Cost of concrete work | 675 | 3 | 10 |
| | 794 | 8 | 0 |
| Credit material | 71 | 10 | 0 |
| Net total | £722 | 18 | 0 |

or per sup. yd. nearly 18s. 1d.

This is a high figure, but irrespective of what has been said above there is no doubt that with better working facilities and more extensive work the cost would be considerably reduced.

### AIDS TO SUCCESS.

To ensure success with this class of road construction every attention must be paid to details, particularly as regards the class and proportioning of the material. If the road, when completed, is to be tar treated a good limestone would appear to be all that is required, and no better results would be obtained by the use of granite.

It is hardly necessary to say that clean material is absolutely essential ; the stone should be washed if at all necessary. The cement should be of the best, slow-setting for preference, each consignment being tested, and it is very desirable to make up a couple of experimental slabs, say, about 12 in. wide and 24 in. long, 6 in. thick, with some of the actual material to be used, breaking it into several pieces at the end of, say, seven days, in order to ascertain if a perfectly solid mass has been obtained with the grading and proportioning with a complete freedom of voids. Before the above work was started, four slabs were made, each with different proportioning, before perfect satisfaction was obtained.

The amount of water to each banker of concrete is also of the utmost importance and, needless to say, should be absolutely clean.

### LABOUR.

A good deal has been said as to the necessity of employing only labour experienced in concrete work, and although such labour would be an acquisition, there is no reason why first-class results should not be obtained with ordinary labour providing a couple of good and experienced men are employed to do the spreading and floating and give general advice to the other men. Out of the twelve men engaged upon the work in question, eight were obtained from the labour bureau with no experience ; the remainder were corporation workmen, two being given extra money for semi-supervision.

Transverse joints have been advocated by some for this work, whilst others have considered this a detriment owing chiefly to the wearing away of the edges of the joint. Mr. Shellard thinks that so long as good longitudinal joints are provided adjacent to the kerb lines and in the centre, transverse joints are unnecessary ; but until such time has elapsed sufficiently for the test of all expected climatic conditions upon the portion he has seen laid, he prefers not to give a definite opinion on this point.

Mass concrete without reinforcement has also been tried, apparently with some success ; but even supposing ideal foundation conditions existed, the added strength obtained by reinforcement is well worth the extra cost, and where heavy traffic is to be expected—and such a position is the idea of the concrete road—reinforcement is very desirable and very necessary if complete success is the aim in view.

The sand or loam covering of the completed work should on no account be overlooked ; this should be spread as the work proceeds, and also—especially if laid in the summer—the watering of the sand should be persevered with, always keeping the sand damp for at least ten days. This allows the concrete to harden off properly, and consequently will be of much benefit to the surface of the concrete.

The tar treatment of the surface is also a necessary preservative to the concrete surface. It certainly should not be applied too thickly, only a very thin coating being necessary, and probably a second coating will be required at the end of six months.

In conclusion, Mr. Shellard adds that he has carried out very many experimental lengths of roadwork with various methods and patent preparations, and consequently had a perfectly open mind on the question of concrete roads ; but since the construction of the length, and particularly having regard to the excessively heavy traffic which has passed over it within such a short period, he is convinced that, if properly laid and efficiently reinforced with a reliable fabric, this form of road construction will meet all requirements.

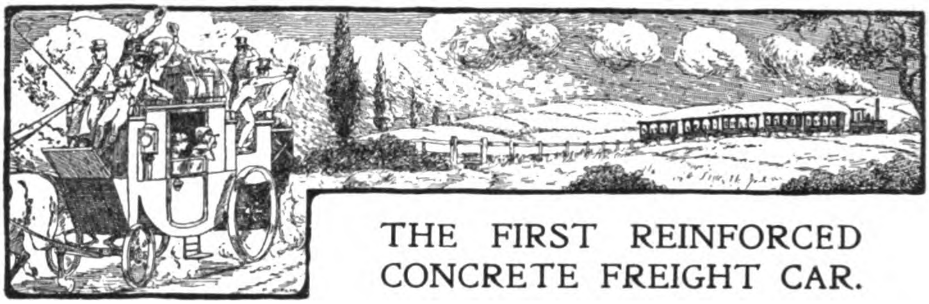
## MEMORANDA.

**Roadmaking.**—At a meeting of Municipal and County Engineers it was stated by the Borough Surveyor of Bury St. Edmunds (Mr. W. D. Harding), in reply to a question put to him, that at present it was possible to construct concrete roads as cheaply as water-bound macadam roads, and it was certain they would see immense strides made as regarded concrete roads (both reinforced and ordinary concrete) in this country.

**Brighton.**—The Brighton Town Council have decided to construct Lewes Road in reinforced concrete at a cost of £5,883.

**Yorkshire.**—A proposal is being considered to concrete the surface of Londesborough Road and Victoria Road, Scarborough.

**Special Announcement.**—It is proposed shortly to publish a book dealing with concrete roads and their construction. A brief account will be included regarding concrete roads that have been laid up to the present in this country, and a chapter will also be devoted to mechanical devices for roadmaking. The book will be well illustrated. Further particulars regarding this book will be given in the March issue



# THE FIRST REINFORCED CONCRETE FREIGHT CAR.

*In a previous issue of this Journal we made short reference to the reinforced concrete freight car which had been built in the United States. We are now able to publish the following interesting particulars as to the construction of the car together with some account of the experiences gained since it has been put into service, in March, 1919.—ED.*

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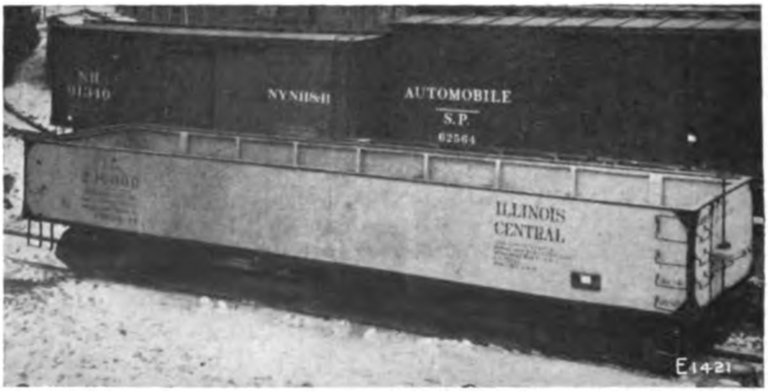
AN innovation in railway equipment, as well as concrete construction, is the reinforced concrete car of the gondola type, invented and designed by Joseph B. Strauss, C.E., president of the Strauss Bascule Bridge Co., and built by the R. F. Conway Co., Chicago. Although the plans for the car were made several years ago and patents were secured covering the important features of the design, the actual construction was started in the fall of 1918. At that time it was thought possible to materially relieve the car shortage, due to the lack of steel, by developing concrete car construction.

The fundamental feature of the design is a steel skeleton body mounted on the standard centre sills and bolsters of the U.S.R.A. 40 ft., 50-ton gondola car, concrete walls and floor, made with a lightweight burned clay aggregate, are contained within the steel frame and, through the reinforcement, are connected to the under frame in such a manner that the bumping and pulling stresses are distributed throughout the entire car body. The car was designed for a capacity of 100,000 pounds plus the usual 10 per cent. overload. End load was assumed at 200,000 pounds with an allowance of 25 per cent. for impact. Unit stresses were limited to 16,000 pounds per sq. in. in the steel and 1,000 pounds per sq. in. in the concrete. The gondola type was chosen for the experiment as equipment



A REINFORCED CONCRETE FREIGHT CAR.

of this type is subject to the severest handling. Dumping devices were omitted to simplify construction, but this feature can be added without difficulty.

The car has an over-all length of 41 ft. 6½ in., and an over-all width of 10 ft. 2⅞ in., with sides 4 ft. 10½ in. high. Steel members of the underframe consist only of the centre sill, which is composed of two 12-in., 35 pound ship channels with ¼ in. by 20½ in. cover plates, and the body bolsters and diagonal corner braces which conform to the U.S.R.A. standards. Six reinforced concrete cross bearers are placed approximately 4 ft. 6½ in. apart, the section varying from 4 in. by 12 in. at the side to 4 in. by 16⅛ in. at the centre sill. The floor is 2⅛ in. thick, reinforced lengthwise and crosswise with ¼ in. round rods. Along the outer edge of the floor is a 3½-in. by 3½-in. angle and at the top of the sides a 4-in. channel, serving as tension members of the sides as well as means of attachment for the side-wall reinforcement. Sides are 1¾ in. thick, strengthened at the bolsters and cross bearers by concrete posts. Across the end of the car is a reinforcing rib 6 in. by 1¼ in. placed 2 ft. from the floor ; a diagonal member extends from the bottom of the end bolster to this rib.

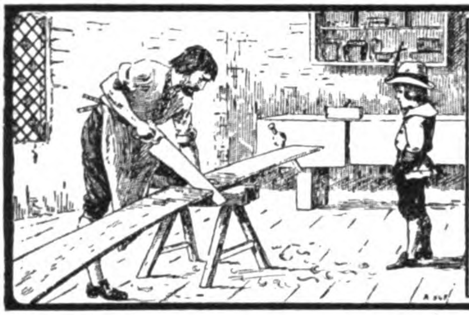
Concrete for the intermediate cross bearers in the floor was cast in forms but the remainder of the floor and walls were built with the cement gun. The forms were placed on the outside of the car, and the cement was shot against them from within. The outside of the car, that is, the surface against the forms, was given a smooth finish, but the interior was left much as it came from the gun.

The use of the cement gun increased the unit weight of the concrete above that computed which was approximately 104 pounds per cub. ft., utilising the light weight aggregate and this increase in weight of the concrete, coupled with the necessity of using somewhat heavier sections than actually required, made the weight of the car about 3,600 pounds greater than the computed weight. With proper facilities for construction, another car of the same size and design could be made to weigh between 46,000 and 48,000 pounds as against the present weight of the car of 53,600 pounds.

Preliminary tests were made under actual switching conditions in the Chicago yards before the car was placed in service. These consisted of turning the car over to a switching crew with instructions to handle it the same as any other car. First tests were made with the car empty ; later it was loaded with damp sand to 10 per cent. overload.

On March 17th, 1919, the car was put into service on the Illinois Central Railroad and was operated for 30 days between the coalfields of southern Illinois and East St. Louis, Ill. At the end of that period it was returned to Chicago and sent to Johnston, Pa., via the Pennsylvania Railroad, with a shipment of steel rails. From there it was sent east where it was under the observation of officials of the Railroad Administration. While in the East the car passed through the car dumper at South Amboy, N.J. At Washington, D.C., it was inspected by the Bureau of Standards and Railroad Administration officials who reported very favourably. Later the car was sent to Cleveland, Ohio, with another load of coal and was passed through the car dumper at Ashtabula, Ohio. Since that time it has been in service on the C. & P. Division of the Pennsylvania System, running between Cleveland and the coalfields.

The car has now been in service for six months.



# MODERN METHODS OF CONCRETE CONSTRUCTION.

**By an ANGLO-AUSTRALIAN RESIDENT ENGINEER.**

*The author of the following article has had extensive experience abroad in concrete work of every description, and the accompanying notes will no doubt interest many of our readers. —ED.*

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THE manufacture of cement and concrete will soon be one of the largest and most widespread industries in the world. It is economical, long lived, fire resisting and a most durable and substantial building material.

The extensive manufacture and use of concrete machinery in this country, as in America, is the thing needful for the economical production of houses of mushroom growth and everlasting stability, that improve with age and require no repairs to roof or building.

With good organisation, efficient management, up-to-date machinery, concrete is undoubtedly one of the materials that can largely meet the requirements of Europe for houses.

Standardising and pre-casting the component parts of houses and erecting large units by crane power is the most economical and rapid method of building construction ; this method is as effective for houses as Ford's system is for building motor-cars.

## CONCRETE COTTAGES.

It was principally the scarcity of building materials in the earlier part of 1919 which gave rise to the discussion on concrete and other modern methods of building construction. There are three methods used in connection with fine concrete construction for building : (1) Reinforced concrete cast *in situ* ; (2) Concrete blocks ; (3) Pre-cast reinforced concrete made in large units by unskilled labour and erected by machinery.

## PERMANENCE.

Concrete has been used since the days of the Romans ; the dome of the Pantheon is of concrete, as also the foundations under the palaces on the Palatine Hill in Rome, and these works show the marks of the forms which were used in those early days, and they are still in excellent condition after many centuries of neglect.

The cement of to-day is unquestionably better than that of two thousand years ago. The product of the old days was a natural cement, and probably not uniform in its composition ; whilst now it is a Portland or artificial cement, which is kept uniform by constant chemical analysis.

ADAPTABILITY.

Peculiar conditions are often arising in the design of large structures, which the lack of reinforced concrete would make difficult and expensive to meet. Special cantilever beams, special floor thicknesses, and specially shaped beams or girders and columns can be worked out in reinforced concrete, when similar details would be considered impossible to those whose knowledge of design was limited to other materials.

SPEED IN CONSTRUCTION.

The Mason warehouse at 134, Johnson Street, Brooklyn, New York, is 40 ft. by 80 ft. in plan, seven storeys and basement in height. After the completion of the excavation, but 48 working days were used to the completion of the roof, and the building was ready for occupation, including plumbing, heating, lighting and elevators, in three and one-half months after the signing of the contract.

The Robert Gair Warehouse, on Front and Washington Streets, Brooklyn, New York, a twelve-storey building with 20,000 sq. ft. to the floor, was constructed in eleven weeks, and the building turned over ready for occupancy in seven months after signing the contract.

A seven-storey building, about 7,000 sq. ft. to the floor, can be guaranteed complete in from four to five months in the United States after the contract is signed.

During 1915 and 1916 the writer was engaged upon a large public works contract in the East. The work comprised the formation of quays, roadways, wharf warehouses, and reinforced concrete wharves, etc. Upwards of 14,000 concrete units, weighing anything between 10 tons and 20 tons each, were precast at the rate of 16 every nine hours, and laid by machinery and native labour under European supervision at the rate of 27 every nine hours, *i.e.*, 20 minutes per block, these blocks being more than equivalent to a rod of brickwork, which takes a bricklayer and labourer 14 days to erect in this country at the present time.

One brick at a time laid by hand and trowel labour, with one man looking on the greater part of his time whilst the bricklayer lays his 300 and less bricks in nine hours, cannot produce the necessary houses required in reconstruction.

Concrete, properly handled, with good organisation and efficient management, is the only method of putting new life into house-building. It is the open door for more unskilled and semi-skilled labour into the building industry. By precasting the component parts of buildings in reinforced concrete on the post, beam and slab system, it is possible to erect better houses at a lower cost, with 75 per cent. less skilled labour and 50 per cent. less labour generally ; no skilled labour is necessary until after the roofs are covered in, and very little after.

ARTISTIC CONCRETE.

The future of concrete in architecture depends very properly upon appearances. The material has established itself unassailably for its structural value. The delight of the public in beauties of colour tone and texture is deeply cherished, and while plain concrete without particular attention to surface treatment is admirably adapted for massive effects, and supplies a pleasing background for vines and shrubberies and flower boxes of the house, concrete must not suffer the limitations which this alone imposes.

Concrete has been criticised for its lack of variety ; this is not the appearance of concrete surfaces made possible by pre-casting with the face exposed for surface treatment, much of which will be seen in the future. The limitation of concrete, which has been criticised as regards tone and colour, has not been, rightly speaking, a limitation of concrete at all. It is merely a limitation of the material which is used to bind together certain aggregates which make concrete.

Concrete work, like other things, has followed the line of least resistance, but education on the subject of making the most of the materials which may properly be used in concrete is becoming more widespread. As pre-cast concrete construction methods and experiments with aggregates assist in revealing the artistic possibilities of the material more fully, the lover of the beautiful in buildings will take more kindly to concrete.

Concrete workers may have good sand, a variety of broken stone, vari-coloured marble chippings and beach shingle, but if they bury all the beauty of the aggregates under an opaque film of cement, the hidden possibilities avail nothing at all.

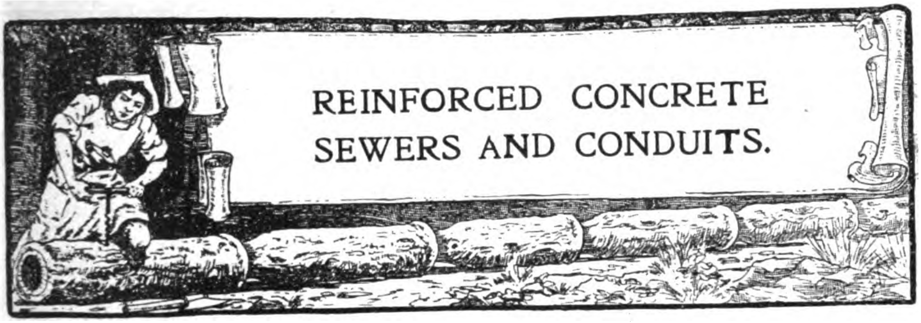
By varying the kind, size and proportion of the aggregates, surface finishes of practically any desired colour and texture may be obtained, the only limitation being the number of different aggregates available and their possible combinations. The colour is obtained from the exposed aggregates and not only by adding colouring matter to the mixture.

A great variety of finishes may be produced by the use of the common aggregates to be found or easily obtained in nearly all localities, such as limestone, granite, or other screenings, marble chips, and different coloured gravels and sands.

To expose the aggregate, the film of mortar that flushes to the surface in casting must be removed, either by brushing the surface with a stiff brush, burlap or the like, or washing the surface with a very weak solution of muriatic acid and water, which should be afterwards washed with water.

If the required colour is not available, or for any reason it is not possible to obtain a surface of the desired tone in this manner, satisfactory results may be achieved by colouring the facing mixture. In face colouring, the mineral colouring mixture should be thoroughly mixed with the materials forming the facing mixture.

*(To be continued.)*



# REINFORCED CONCRETE SEWERS AND CONDUITS.

By Professor E. R. MATTHEWS, Assoc.M.Inst.C.E., F.R.S.E., F.R.San.Inst.

*In view of the increasing use of reinforced concrete for sewer construction, the following notes will no doubt prove useful to many surveyors and engineers.—ED.*

REINFORCED concrete lends itself admirably to the construction of conduits and sewers which are either with or without internal pressure. It has been greatly used for this purpose in America, but it will not withstand heads of considerable magnitude, and the author does not, therefore, favour its use for rising mains. Plain concrete for sewers and conduits is wasteful.

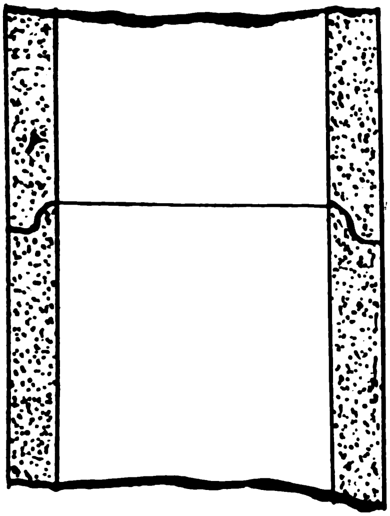


FIG. 1.

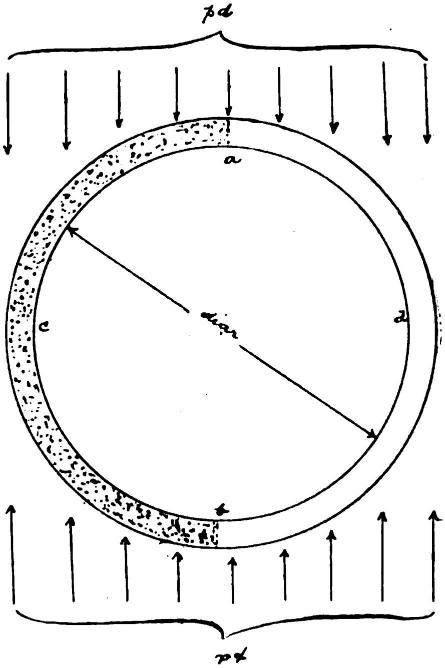


FIG. 2.

Most of the new sewers in San Francisco are of reinforced concrete, as are also those of Paris. Sewers of this class are usually (where above 3 ft. 6 in. in internal diameter) built in monolithic lengths of 40 ft. to 50 ft., the object being to avoid if possible shrinkage cracks, which the engineer abhors. There is no reason why the monolithic lengths should not be greater, but if so, additional longitudinal reinforcement should be inserted, and temperature stresses must be met by further reinforcement.

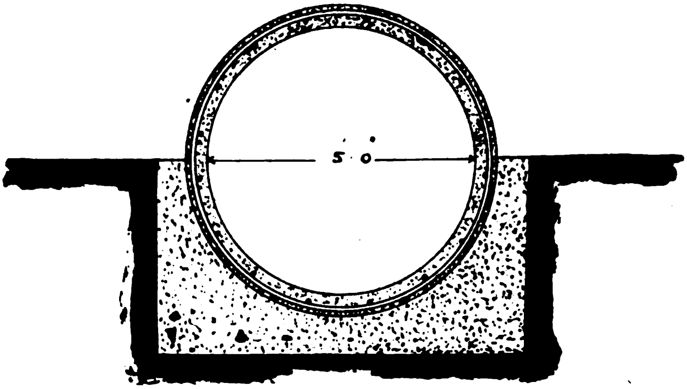


Fig. 3.

The question is often asked: Can conduits under ordinary heads be made watertight? Yes! When the head does not exceed, say, 70 ft., they can.

The matter of forming the invert in large sewers with vitrified brick is one which must be decided by the engineer; some consider that unless the invert is paved in this way, the concrete will (if there is much detritus passing through the sewer) soon wear away; on the other hand, it is claimed that if the conduits and sewers have had three months' (at least) set before use, preferably more, no wearing action will be experienced.

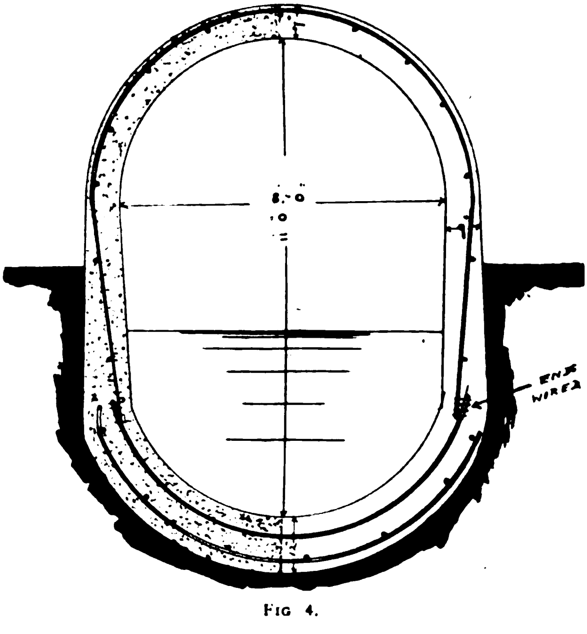


Fig 4.

By using reinforced concrete quite 30 per cent. is saved in cost, and this is a considerable amount in these days when materials and labour are so very costly.

Up to, and including, diameters of, say, 3 ft. 6 in. it is much cheaper to use pipes already moulded than to construct the sewer in place; the pipes should always be reinforced, and they should have been made at least six months before use, a guarantee from the manufacturers being necessary. A pipe of this class, say, 3 ft. diameter, will be about 3 in. in thickness, with joints as shown in the diagram, *Fig.* 1, whereas if moulded in place the thickness is not usually less than 4 in. The use of pipes already moulded has the disadvantage that there are joints every 3 ft. or 4 ft., and leakage is likely to occur at any of these, whereas a monolithic structure only has joints every 40 ft. or 50 ft.

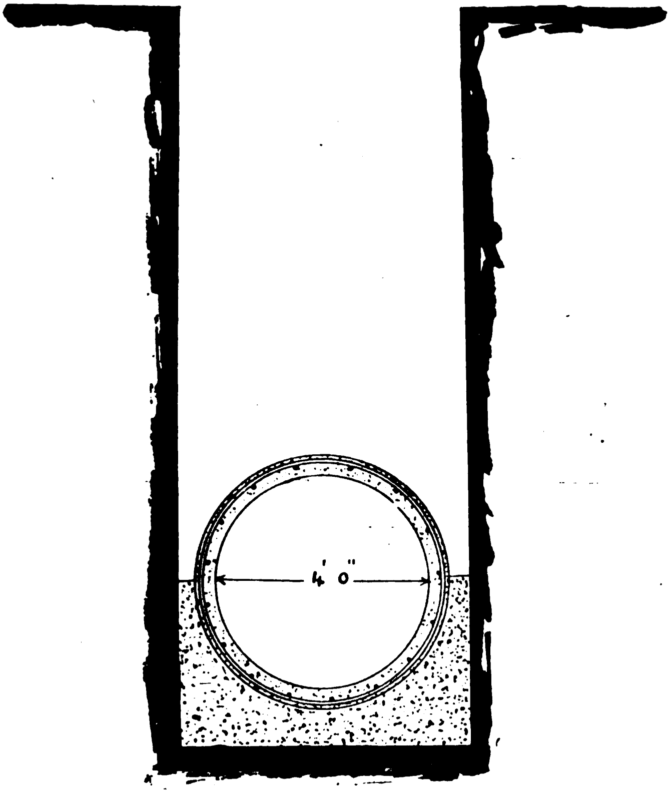


FIG. 5.

The author has laid many of these moulded pipes, and at various depths, and he recommends any who may be using them to set them in a bed of concrete; and to haunch them up at the sides, as shown in *Fig.* 5, so as to help them to resist the pressure of the earth filling in the trench, and thus avoid "bellying" of the pipe (due to downward pressure) which often occurs.

*Fig.* 5 represents a sewer or conduit constructed *in place*, reinforced by hooping as shown, and by the insertion of small steel bars (say, ¾ in.) running longitudinally, and spaced about 10 in. apart.

The bending moment in circular sewers in reinforced concrete under a uniform load may be found as follows :—

It is assumed that the pressure on the pipe is exerted in parallel lines (downward and upward), as shown in *Fig.* 2, and is uniformly distributed with respect to a plane perpendicular to the direction of the pressure.

Let $d$ = diameter of pipe.
$p$ = pressure per unit area as measured perpendicularly to the pressure.
$M$ = bending moment in pipe in a length of one unit.

*The following equations result :—

$$M_a = M_b = \tfrac{1}{16} pd^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (1)$$

$$M_c = M_d = -\tfrac{1}{16} pd^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (2)$$

If the lateral pressure, measured in a similar way, be $p^1$ per unit area, then the moments due to this pressure will be :—

$$M_a = M_b = -\tfrac{1}{16} p^1 d^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (3)$$

and

$$M_c = M_d = \tfrac{1}{16} p^1 d^2 \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (4)$$

Usually the lateral pressure will be much less than the vertical pressure ; probably not more than one-fourth or one-fifth as much.

*Fig.* 3 shows a 5 ft. culvert, constructed in place in reinforced concrete, and carried partly below and partly above the ground, the thickness of the shell is 4½ in., and it is reinforced by the insertion of steel bars longitudinally and transversely. The author suggests that, unless the ground is particularly good, the conduit should be carried on a bed of plain concrete as shown.

*Fig.* 4 represents a section (designed by the author) through a very large aqueduct ; this would be built in lengths of, say, 50 ft., and reinforced as shown by longitudinal and transverse reinforcement. The material lends itself well to large structures of this kind, as well as to pipes and small conduits.

## MEMORANDUM.

**The Concrete Institute.**—We would call especial attention to a course of six educational free public lectures which are being given at the Institute. The first lecture was given on February 6th by Mr. H. K. G. Bamber, F.C.S., etc., entitled " Demonstrations on the Practical Testing of Cement." The dates for the remaining lectures are February 20th, March 5th and 19th, April 9th and 16th. The lectures will be given in the Council Chamber of Denison House, 296, Vauxhall Bridge Road, Westminster, S.W.1 (close to Victoria Station), and will be of approximately one hour's duration ; they will be illustrated by diagrams, photographs, specimens and apparatus, as necessary.

The syllabus for the remaining five lectures is as follows :—February 20th : " Some Points in Reinforced Concrete Design." By Mr. H. Kempton Dyson. March 5th : " Some Properties of Steel." By Mr. Ewart S. Andrews, B.Sc. (Eng.). March 19th : " Notes on the Practical Application of Reinforced Concrete." By Dr. Oscar Faber, O.B.E., D.Sc. April 9th : " The Uses of Concrete." By Mr. T. J. Clark. April 16th : " Submission of Plans to Local Authorities." By Mr. E. Fiander Etchells, Hon. A.R.I.B.A., Assoc.M.Inst.C.E., etc. There is no fee for the course ; admission will be by signing the attendance book.

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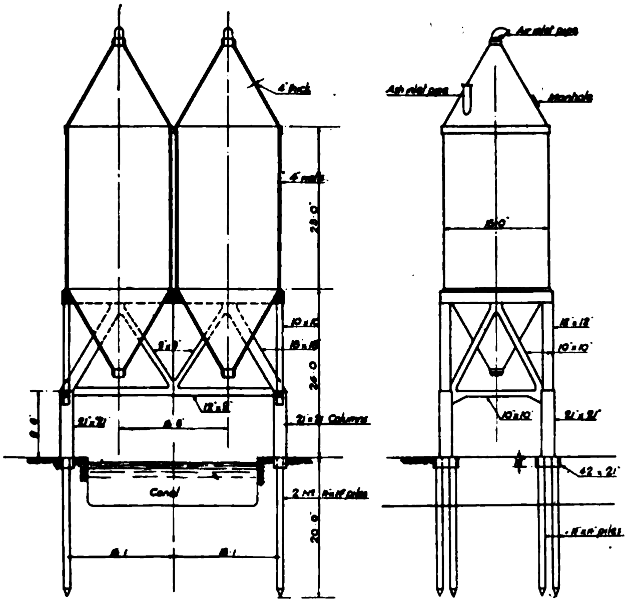
* *Principles of Reinforced Concrete Construction.* By Turneaure and Maurer. (John Wiley and Sons.)

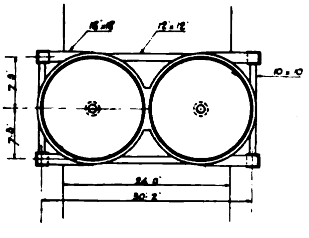
# CONCRETE ASH RECEIVERS.

THE use of reinforced concrete for the construction of ash-receiving plant is quite a new departure, and the installation described below is, we believe, only the second which has been erected in this country. Owing to the fact



LONGITUDINAL SECTION

END ELEVATION

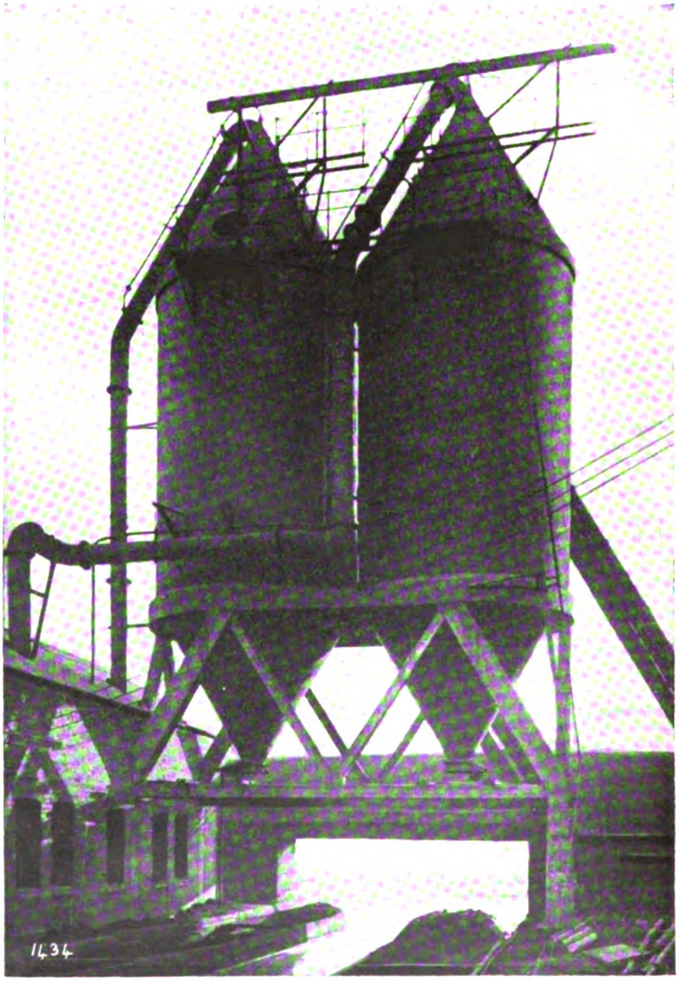


PLAN THRO' HOPPERS

REINFORCED CONCRETE ASH RECEIVERS.

that the temperature of the ashes reaches as high as 500° F. and that they are drawn up to a height of 50 ft. by the suction caused by a vacuum in the receiver the conditions are unusually severe. The plant has been in operation over two months, with satisfactory results.

The receivers have a capacity of 75 tons, and from 70 to 80 tons of ashes are handled in the plant daily As the ashes are drawn to the top of the cylinders by suction, the latter are, of course, airtight. The framework is carried on four columns, 9 ft. 6 in. high by 21 in. square, which support trusses spanning a distance of 30 ft. 2 in. across the canal. Each of these four columns rests upon piles 20 ft. long by 14 in. square. The two triangles forming the trusses across the canal are tied at their apexes by a strut forming part of the beam on which the receivers rest ; the ends of the receivers are supported



Reinforced Concrete Ash Receivers.

by single triangles. All the trusses are about 14 ft. 6 in. deep. The beam which directly supports the cylinders is arranged as a stiffening ring, and the inside of the beam forms the top of the bottom cones. This ring is about 18 in. deep by from 12 in. to 18 in. wide. The dimensions of the other concrete members are clearly shown on the sections.

The receivers are 46 ft. in height and 15 ft. in diameter, the cylindrical portions being 23 ft. high, and the cones at top and bottom 11 ft. 6 in. The walls are 4 in. thick throughout. Indented bars were used for the reinforcement.

This plant is in use at the Smethwick Power Station of the Shropshire, Worcestershire & Staffordshire Electric Power Co., the construction being carried out by Messrs. Wilson, Lovatt & Sons, Ltd., of Wolverhampton. The designs for the reinforced concrete work were prepared by the Indented Bar & Concrete Engineering Co., Ltd., of Queen Anne's Chambers, Westminster, S.W.1, who also supplied the indented bar reinforcement.

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## MEMORANDUM.

**Reinforced Concrete for Mine Work.**—At a meeting of the Midland Institute of Mining, Civil and Mechanical Engineers, Mr. T. J. Guéritte, Councillor of the French Board of Trade, etc., read a paper on the " Application of Reinforced Concrete in Mines." The author pointed out that the applications of this form of construction for colliery work have become so numerous that a whole paper could be devoted to their description.

This journal has repeatedly drawn attention to the advantages of using reinforced concrete for colliery works, principally on account of its fire resistance and the large reduction that can be effected in maintenance charges. In the course of his paper, M. Guéritte spoke of the rapid progress made in the use of reinforced concrete at mines during the last ten years, and gave many instances of its application. The pioneers in this country in the application of the material to heapsteads were the Bentley Colliery Co., Doncaster. They built their No. 1 heapstead in 1910, but at that time, although they used reinforced concrete for the bulk of the work, including the lower part of the back stays, it was felt that further experience was required before adopting it for the upper part of the pithead frame, and the latter was consequently made of steel in the usual way. When in 1914 it became possible to proceed with the heapsteads at No. 2 pit, it was found that the behaviour of No. 1 heapstead had given such thorough satisfaction that no diffidence was experienced in deciding to construct the complete frame in reinforced concrete.

The lecturer described many other uses to which reinforced concrete had been put on the surface works of collieries, including airtight chambers, fan-chambers, engine-room floors, coal-hoppers, bunkers, chimney stacks, culverts, and bridges.

Underground the material had been adopted for insets in order to avoid any danger from fire. Reinforced concrete linings were extremely valuable in the event of an explosion, as they held well together. The obstruction of galleries due to the destruction of ordinary linings by the force of explosions had on various occasions intercepted the escape of men and resulted in loss of life. The greater security offered in that respect by the use of reinforced concrete was consequently worthy of serious consideration. Reinforced concrete props had been used, and marked improvements might be expected in the near future, but although, personally, he was a great and all-round believer in reinforced concrete, he considered that the manufacture and use of reinforced-concrete pit-props was still in an experimental stage.

The paper was followed by an interesting discussion.

## RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

*It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.*

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### *THE CONCRETE INSTITUTE.*

# THE USE OF ELLIPTICAL VAULTING AS A PRIMARY FACTOR IN CONTEMPORARY ARCHITECTURE.

By **MAURICE S. R. ADAMS, A.R.I.B.A.**

*The following is an abstract from a paper read before the Concrete Institute on December 18th. In a recent issue of this journal we gave some short particulars and illustrations regarding Mr. Adams' system.*

In earlier days, factors governing architecture and modes of construction were necessarily limited, so that confusion of thought respecting fundamentals and ideals as witnessed to-day was not possible, save within very limited margins.

Since the term architecture is made, at the present time, to bear such varied and contradictory interpretation, I may perhaps be excused if I put before you at the outset what I conceive to be the real definition.

Rightly or wrongly, I hold that man has in his nature something of the divine element, which he is able to express in the work of his hands. Every individual is not able to interpret or utilise this power; but any work expressing it in a marked degree becomes acknowledged as one of genius.

Architecture is more than bricks and mortar, and in the best examples something precisely similar is manifested behind the actual and visible stones. Therefore, in using the word architecture, I include only such buildings as express something more than structural stability and practical efficiency.

The art of architecture is the power to interpret Nature in building. No architecture ever was or ever will be beautiful which has not the elements of Nature within its conception. This theory cuts at the root of modern practice and of that method of design which treats of architectural expression as surface decoration only, without reference to the construction.

Features such as columns, porticoes, and pediments whose forms originated in structural necessity, are now commonly employed as mere ornament. From this conception of architecture I beg to differ, and I maintain that architectural forms must be evolved from the construction, which they are bound to express.

Broadly speaking, there are two main constructional forms—the arch and the beam. Both have been used from time immemorial in all countries. The beam is probably of earlier origin, but the arch, by virtue of its more scientific character for anything but the smallest spans, has had far greater influence in the development of style. My view is that beam construction as practised to-day is not only unscientific, but unarchitectural. Beams of uniform section throughout their length contain a large proportion of waste material, which far from increasing the strength of the beam actually decreases it by reason of the extra load the beam has to carry. In a beam supporting an equally distributed load the weakest point is at the centre of the span. In order to make such a beam truly scientific and architectural, the cross section would have to be reduced in exact proportion to the diminishing strength required. This would be virtually impossible to do in practice owing to the difficulties of manufacture; also for other reasons it would not be at all desirable. But here at once we come up against the question of the natural stresses of tension and compression; and I would lay it down as a maxim that as far as possible all tensional stresses should be eliminated and compressional stresses relied upon.

If the theory of architecture I have outlined is true, naturally it would be expected that as knowledge of natural laws increased with each succeeding generation, this would be expressed in the buildings, resulting in the production of ever finer and increasingly magnificent works of architecture. Actually this was the case in England up till the time of the full and final development of Gothic architecture, during which period the principles I am advocating were exclusively followed. Gothic architecture was the finest and most wonderfully natural mode of building the world has produced.

All this was changed when the vertical element in the design, which formed the keynote to the style, was gradually replaced by the horizontal element. This resulted in the final collapse of the style, for Gothic architecture is not possible with a horizontal motif. Hence came a departure from true architectural principles, and architects began the period of false tradition which has been followed through a variety of phases right up to the present day.

Many so-called revivals have taken place, but real architecture is possible only by giving expression to current needs through current methods of construction in current materials.

Any literal attempt, therefore, to revive a former style or period of architecture must fail from an artistic point of view. Architecture is a live Art, expressing current ideas.

If ever a true style of modern architecture is to be evolved, it will only be possible by allowing full scope to every advantage and facility which modern science affords for building, guided by a strict interpretation of natural laws and principles as now advocated.

### CONCRETE AS A STRUCTURAL BUILDING MATERIAL.

Concrete, as developed by modern science, I conceive as being the finest structural building material the world has so far produced. Its chief advantages are adaptability, great strength, durability and monolithic character. The age of concrete building has not yet begun, and I foresee great possibilities for a future style of architecture, when the real characteristics of concrete are realised and the true principles of architecture are revived.

### ELLIPTICAL VAULTING.

Coming now to the special subject of this Paper " The Use of Elliptical Vaulting as a Primary Factor in contemporary Architecture." The culminating point in all systems of construction and styles of architecture is the problem of roofing. Even where the roofs are flat the problem is not so simple as might at first be imagined, because when spans exceed more than moderate size, it is necessary to introduce secondary beams or girders, and these result in the application of concentrated loads at fixed points, instead of being evenly distributed over the walls. Such loads, augmented from floor to floor, must necessarily have considerable influence on the plan, and must be carefully considered at the outset.

The walls in ordinary buildings serve two purposes—namely, to support the roof and to screen the sides.

**Advantages.**—An advantage of semi-elliptical vaulting is that the vaults may spring immediately from the floor level instead of being superimposed at a higher level upon walls or piers, as in Gothic architecture. Thus all thrust is absorbed at the ground level and no system of buttressing is required. Further, the vault or roof being thus self-supporting, all structural or weight-bearing walls are eliminated from the building. The gable walls closing the ends of the vaults are in effect panels rather than walls, and consequently their thickness may be reduced to that of a partition. I have built gable walls to cottages only 4½ in. thick; but from the fact of their being tied in by the concrete vault they possess remarkable strength, and the result is more permanent than a brick wall of twice the thickness as used in ordinary construction. Buildings roofed with elliptical vaults are in reality all roof.

The comparative weakness of ordinary construction may be measured by the extent to which the beam principle is employed. A wall, whether of brick, stone or concrete, is in effect a continuous strut. Its strength must be sufficient to resist bulging under superimposed loads, to be self-supporting and to withstand outside forces such as wind, rain, vibration and sudden shock.

In all ordinary buildings the walls depend for their stability almost entirely on side abutment, whether by cross walls, end walls, or by roof or floor ties. In buildings where the construction is uniform, as with reinforced concrete, or where floor and roof construction is of steel and concrete, the structure will be more or less permanent. But where soft timber is used for floors and roofs, as in ordinary house construction, the results are not permanent, because the walls depend for stability almost entirely on the floor joists and roof ties, Cut out the floors and roofs, and it will not be long before the thick walls come toppling down by virtue of their own weight, if they are not blown over by the wind.

The remarkable stability of vault construction, whether of stone or concrete, lies in the fact that the vault substance is built, not vertical, but falling, and consequently the direction of gravity cannot be changed by any slight settlement in the foundation. The very weight of the material used serves to increase the vault's strength. Within the limits of compressional strength a vault may be uniformly loaded to any extent desired. The loaded vaults will be actually stronger than the unloaded vaults. Very different is the case with beam construction in which tensional strength is strictly limited within a comparatively small margin of safety. Any surplus overloading at once reduces strength, and places stability in danger.

The extraordinary strength and durability of Gothic vaulting are due to these facts. The old Gothic builders were masters of construction. From actual experience without elaborate calculations to help them, they understood the principles of thrust and counter-thrust far better than the majority of engineers and architects do to-day, who place far too much reliance on mathematical calculations and theoretical stress diagrams.

A simple cross vault consists of four arched compartments, each of which tends to topple inwards. The four compartments exactly counter-balance each other, resulting in great constructional strength compared with the amount and weight of material employed. Any tendency to spread in one compartment is exactly counter-balanced by the same tendency in the adjoining compartment.

The first point in favour of semi-elliptical vaulting is that greater strength is produced with less material than is possible with any other form of construction, and it is therefore scientific and true to Nature. For this reason it may be adopted for architectural purposes as considered from the present point of view.

I include as semi-elliptical all curves approximating to this form, such as parabolic and pseudo-elliptical curves.

It is, of course, desirable with all forms of roofing that the loads thereon should be supported at as few points as possible, that the plan may not be unduly interfered with. By steel construction the number and size of the stanchions or piers may be reduced to a negligible quantity. With cross vaulting the results in this respect are at least equal, and in some cases superior, to steel beam construction, since the floor space is entirely unrestricted, save at the four corners of each bay. By means of reinforced concrete the bays may be of any size desired, the construction requiring less material and giving greater strength than would be possible by any other means.

**Architectural Considerations.**—We now come to the architectural considerations involved by the adoption of elliptical vaulting.

Architectural expression may be divided into two classes; constructional forms and ornament or decoration. In designing, the architect must thoroughly understand the requirements and purpose of his building, since practical considerations come first and foremost. To solve successfully the problem he must meet these requirements both in letter and in spirit. Practical considerations of minor importance must be made subservient to first essentials. Nothing must be intentionally disguised or falsely expressed.

Having thoroughly grasped the requirements of this building, the designer will consider questions in connection with the site, aspect and prospect, the nature of the soil, and any differences in level, so that his plan may serve to the best advantage.

In recent years a strange and wholly illogical doctrine has arisen, which teaches that design has nothing in common with the construction, and that the best architects are those who most successfully disguise modern steel frame construction with applied architectural forms. Modern construction, we are told, must necessarily be very ugly if left to express itself naturally.

In buildings of this kind, which to-day are the rule and not the exception, the larger and more important rooms are provided with sham plaster ceilings representing groining. Not infrequently sham columns are attached to the walls, and apparently support the vaulted ceiling.

Put quite bluntly, architecture has become almost a lost art, and only a small proportion of modern building deserves to rank as architecture.

On the principle of architectural truth I base my theories of architecture.

Architectural design, as I understand it, consists in adjusting the several parts and the construction of a building so that the proportion or relation of parts in point of size produces an effect of harmony and unity. Unity of composition is produced by a definite ratio of parts because of the common element thus introduced between features otherwise having little or nothing in common.

Unity of idea is essential in architecture because it is found in Nature. A leading thought should run through an entire structure.

The designer, having determined the several proportions of his building, will be free to ornament, enrich and humanise it by applied ornament.

Works of architecture should be designed from the inside and not from the outside. The internal form of a building will be determined by practical considerations and structural necessity. The outside of a building may be left to take care of itself, when it will express quite naturally the form of the interior and true shape of the building.

There are three kinds of proportion in architecture—the vertical, the horizontal, and the neutral or square.

With former methods of construction only three pure styles of architecture were possible—namely, the Greek or horizontal style; the Gothic or vertical style; the Byzantine or square style. All other periods of architecture were impure in style in varying degree measured by the departure from the basic proportion adopted.

With new methods of monolithic construction in reinforced concrete, three new and pure types of design became possible, opening up a wider field for design than the world has ever seen. We can at first do no more than start on the same principles from which all the great styles were evolved. If we do what we at least conceive to be right we need not fear criticism in an age when the very principles of art are so little understood.

I will now offer a few remarks on some designs and buildings constructed with roofs of semi-elliptical reinforced concrete vaults.

*Design for a War Memorial Church.*—Mention may be made that it was in trying to solve the problem of modern church design that I hit upon the idea of elliptical vaulting.

Funds available for church building, in the majority of cases, were far too small before the war. Now, with the cost of building increased three or four times, the task of building on pre-war methods becomes impossible.

The plan of my concrete church is essentially modern, and adapted to modern needs.

The nave is wide and no piers or columns obstruct the view of altar or pulpit. The value of ritual in public services is now generally recognised; therefore the chancel and sanctuary are wide and spacious, so that the worshippers may observe the movements of the priest as he celebrates the divine office.

The building is simple in form, consisting of three square bays covered by semi-elliptical vaults, which spring immediately from the floor level, and which consequently produce no thrust. The nave is 40 ft. wide, and 40 ft. high measured inside from pavement to crown. It is therefore of neutral or square proportion. Square proportion is recognised throughout the design, as in the semicircular arches of the arcades and in the spacing of the columns; in the semicircular and lozenge-patterned tracery of the clerestory windows; and in the design of the marble pavements and marble decorations of the arcades. In this regard the design bears resemblance to

Byzantine architecture ; but since the materials and mode of construction employed are essentially different, the treatment cannot with any degree of accuracy be termed Byzantine. The elliptical cross vaulting as here employed when carried out in reinforced concrete would produce a building of exceptional strength and durability besides being very economical in material. The curving of the vaults tapering inwards gives the effect of increased height by intensified perspective. This effect is well demonstrated by the plaster model of the church.

Externally the form of the building is produced naturally by the vaulting. No attempt is made at disguise, and since concrete may now be rendered waterproof, no roof mask is required as in Gothic architecture. The external effect as demonstrated by the plaster model is, by some, considered to be too crude. This no doubt is due to the absence of excessive ornament such as we are accustomed to in modern buildings and to the limitations of a small scale model. In execution the roofs could be tiled or covered with lead or copper, or simply rendered smooth in cement. In either case the effects of weathering would produce the texture required to avoid monotony in appearance. A copper covering in most cases would prove too expensive, but a green oxide effect might possibly be obtained by artificial means. A quite legitimate form of treatment would be to embed either plain red or glazed coloured tiles in the concrete ; zig-zag and other simple patterns could be used. Plain cement becomes very dreary in appearance after a few years' exposure. Waterproofed cement is better in this respect besides being more durable. The mossy growth so common to cement work after long exposure does not occur where the cement has been waterproofed.

*Other Buildings.*—Elliptical vaulting may be employed to advantage for all classes of buildings requiring large covered areas of low proportion free from obstructions, such as factories, stores, tram sheds, etc. In these cases the ellipse is placed on the long, instead of the short, axis, as in the case of the church.

To illustrate this type of building I have designed and modelled a factory building.

The factory consists in plan of three rows of four bays each 30 ft. square. The shop therefore measures 120 ft. long by 90 ft. deep, with a height of 15 ft. from floor to crown of vault. With this form of roof only six internal columns are required, and these are spaced at 30 ft. intervals. With ordinary steel construction the girders supporting roof principals would necessarily be very heavy over so wide a span and intensified by the irregularity of the loadings from the more closely-spaced roof principals..

The entire absence of dust pockets makes a vaulted workshop very sanitary. Such buildings are readily cleaned, and when desired may be washed out with a hose pipe.

In the example illustrated, top lighting is arranged in the north compartment of each bay. Other methods are possible, such as by means of lanterns placed over the centre of each bay. Ample side lighting is arranged on all sides of the shop.

Offices and lavatories, etc., are arranged along the west side of the shop with separate entrances and check offices for men and women. Sliding doors are provided at both ends of the building to facilitate the handling of goods on receipt and despatch.

Naturally as an architect I am primarily interested in the architectural aspect of building, but it so happens that it is possible to erect houses by my sustem of reinforced concrete construction both more cheaply and quickly than by ordinary methods of building. Unlike all other systems of construction which aim at economy by reducing the amount of material employed, and which must, therefore, be considered as being more or less temporary, my cottages, owing to their form of construction, are absolutely permanent.

The first bungalow has been erected at Ruislip, Middlesex. The design of this and other bungalows has been standardised in order that the greatest economy may be effected. The living room measures 21 ft. 6 in. by 17 ft. 6 in. by 9 ft. 6 in. high. This is much larger than is usual for so small a cottage and forms the principal feature of the house. The hall is fronted by a verandah, from which it is divided by folding glazed doors. When these doors are open the hall and verandah become what is virtually an open garden-room suitable for meals in summer. The hall has a southern aspect, and looks on to the garden court enclosed by pergolas and high trellis.

At the back of the hall, separated by a lobby, is the bath room and lavatory. There being no hot water service, the bath is connected and supplied with hot water from a gas copper placed in a corner of the bath room.

The accommodation includes two double bedrooms, one single bedroom, passage, and small kitchen scullery. Special fittings to reduce housework as much as possible are supplied including cabinet, large sink with draining racks, flap table, etc. The sink is supplied with hot water from a small geyser, and for cooking there is a gas cooker.

The Ruislip bungalow is straw-thatched over the concrete vaulting. The floors are boarded except in bath room and kitchen, which are paved with granite flooring.

Similar bungalows are in course of construction at Herne Bay and Hounslow and a number of others are to be built at Broadstairs, Bexhill, Bushey and Ruislip.

**Constructional Methods.**—So far I have not touched upon the constructional methods employed in carrying out buildings on this system.

The Ruislip bungalow has a roof constructed of self-centering metal reinforcement attached to steel diagonal ribs. The gable walls or panels which close the ends of the vaults are of hollow concrete blocks trimmed in execution to a wooden guide. The walls are finished with sirapite plaster inside and Pudloed cement outside, distemtempered white. At Ruislip I omitted all foundations, merely stripping the turf and forming a reinforced concrete raft over the site. The brick fireplace in bedrooms proved expensive; therefore, in all other cases, gas fires have been substituted in the bedrooms, the flues being taken up in the partitions to a brick stack carried on the concrete vault. The omission of the brickwork effects a big increase in the floor space, besides reducing the cost. Self-centering temporary supports about 4 ft. apart are all that is required, thus obviating all close-boarded shuttering. Thorough tamping with reinforced concrete work is essential, and I found the self-centering rather apt to be springy and throw back the concrete during the tamping, especially on the sloping surfaces of the vaults. At the lower portion of the vaults, where some form of external shuttering would be necessary to keep the moist concrete in position, the difficulty was overcome by building up a casing with 2-in. concrete slabs in place of the shuttering. This method proved quite satisfactory.

At Herne Bay a special form of climbing wood shuttering was designed for use in place of the concrete blocks in the gables, so that the gables might be cast monolithic in situ. The time, however, required to erect and take down the shutters more than counter-balanced the advantages of this method. I have, therefore, reverted to the use of concrete blocks.

For purposes of economy and facility in execution I have cut out the whole of the steel reinforcement in the construction of my vaults. The vaults are constructed with pre-cast reinforced blocks 4½ in. thick. These are specially cast in constructed boxes by a method which gives the blocks the proper curve required and also the correct mitre at the ends next the diagonal lines of the vaults. Eight casts are required to each bungalow, and this may be done by two labourers in eight days, or by four labourers in four days. The blocks are cast in stacks and may be unstacked after about four days. They require at least seven further days to mature before use.

One of the secrets of successful house construction in concrete is the use of a suitable aggregate. For my cottages I use either washed pan breeze or crushed clinker, which must be reasonably free from sulphur. No sand is required with these aggregates, which, when mixed with cement in the proportion of one to six, make a splendid building material. The substance is too porous and breathes too freely for sweating to be possible, and is, to my mind, superior to brickwork for house construction. The concrete must be mixed fairly dry and thorough tamping is essential. In wet weather watering of the blocks is unnecessary; in fact, the difficulty is rather the opposite since the blocks take too long to mature if kept saturated. In hot summer weather, however, sprinkling is necessary for a few days after manufacture to make up for evaporation, and the blocks must not be allowed to dry white too quickly.

For my bungalows the roofs are finished either with thatch, or tiles, or merely rendered with Pudloed cement or granite and cement. The rendering should not be applied as a continuous covering, but should be divided up into squares of 5 or 6 ft. by means of a paper joint which may be subsequently filled with hot mastic or some composition such as "Matex."

## DISCUSSION.

**Dr. J. S. Owens** said he was always at a loss to understand what people meant when they talked of "beauty." It was interesting to try and define the word, but it was very elusive. He thought the word originated in utility, that a thing gradually became to be regarded as beautiful because it was useful. That, perhaps, was a view which would not be accepted generally, but there were many cases in which our feelings, developed to indicate beauty or pleasure, were entirely based on utility. The paper also said that there were certain natural laws of special importance with reference to architecture and the first of these was truth. Further on the paper said: "Nature never employs more material for the formation of a particular object than is required." That was exactly the opposite of what he would have said; it appeared to him that Nature always employed a lavish amount of material, and that if she wanted to get any result she got it by trying so many methods that she was bound to succeed with one. Of course, one must always remember that in speaking of the design of things by Nature, strictly speaking, there was no design at all: we had what was left after Nature had been operating for untold ages. The mountains were the result of weathering, it was not a matter of design. Further on in the paper the author said: "I would lay it down as a maxim that as far as possible all tensional stresses should be eliminated and compressional stresses relied upon." Possibly that would appeal more to the mass concrete men than to those who worked at reinforced concrete. He himself did not think much value would be got out of reinforced concrete unless it was allowed to stand a little tension. He thoroughly agreed with the reference in the paper to sham plaster ceilings representing groining, sham columns attached to the walls and apparently supporting the vaulted ceiling. We were always making shams, and if a building was of one material it was a hundred to one that the artist would pretend it was some other material. One general thing he would say was that it was a great mistake when designing a concrete building to imitate brick or something else.

**Mr. E. S. Andrews** said that the author had said that architecture was a lost art, but it seemed to him rather to be a science that had not yet been found. The general principle that there was a spirit or soul to be expressed in design was a thing that he fully appreciated, but what he wished architects and the artistic fraternity to understand was that the engineer in his work had the same outlook. The thing we called soul was that part of the design which showed the personal touch, and made the design of one man different from that of another, although starting from the same point of view. With regard to the author's reference to tensional stresses, it seemed to him that the fundamental fallacy in the author's argument was the idea that in an arch there was only compression and no thrust. Without wishing to be aggressive, he would deny that even with Mr. Adams's construction there was no thrust, and he also denied that there could be no tension. In any arch construction, for any given system of loading, a theoretical form of arch could be designed which for that condition of loading would only have compression stresses for its members, but there would always be a thrust on its base, and directly the loading was altered without altering the shape of the arch, tension stresses were introduced. In the case of the building which formed the subject of the paper, the wind blowing on one side of the building caused tension on the other side. Whether the arch rib form of construction, which was the basis of this construction, was more economical than the beam form was another point; he would like to have it investigated because he was not satisfied on the point. What he wished to contend, however, was that it was impossible to have an arch in which the members were only in compression. Referring to the author's remarks regarding the Gothic builders, Mr. Andrews said that the conditions of building in Gothic times were totally different from those of to-day, and he did not think we knew how much the old masters knew of the science of building as they understood it to-day. He was inclined to think that the old masters had no knowledge comparable with that which engineers and architects, if qualified, had to-day. Far from placing too much reliance on mathematical calculations and theoretical stress diagrams, he thought the great fault to-day was that we placed too little. Too little attention was given to the purely scientific and mathematical side of the treatment of stress. Seeing that the professional work of the architect so largely dealt with factory and domestic work, it was a great pity that their education standpoint should be one of mediæval art, and it would be much better if they graduated from the faculty of science rather than the faculty of art. On the whole, he thought the author was right in principle but wrong in some of the details.

**The Secretary** read a letter from Mr. E. Fiander Etchells, who expressed the opinion that the word "architecure" should be used to include only such buildings as expressed something more than structural stability and practical efficiency. A similar idea had been expressed by Ruskin, but he did not think architects would accept the idea as it stood. Apparently it would remove from their province many industrial and utilitarian buildings, which were only designed with a view to structural stability and practical efficiency. The acceptance of this doctrine by building owners, ground landlords, estate agents, builders and certain Government Departments had led to architects not being consulted more frequently in many schemes where they might co-operate with advantage. He preferred the definition of Sir Henry Watton, "Architecture is the art of well building."

**Lieut. Lawson S. White, R.E.,** said he could not agree with Dr. Owens in his remarks about Nature. Dr. Owens had referred to the mountain as an example of Nature's building, but we might as well refer to the slag heap as an example of man's architecture. A better example would be the honeycomb, which might be adapted to the modern concrete elevator or grain storage plant. There was also the question of the waste of room ; the buildings Mr. Adams had shown were all of one storey, and he would like to see the adaptation to a two-storey building. In regard to wind causing tensional stresses, surely such stress could only come into operation so far as material was concerned when the compressional stresses were overcome in that way.

**Mr. Allan Grahame** thought a designer or constructor ought to be an architect as well. A thing might be constructed in such a way as to be absolutely correct as far as utility was concerned, and yet be an abortion to the eye ; a thing could be designed so as to be not only fit for its work but to have beauty as well, and that was why it was necessary for the architect to correct the work of the engineer. The author had deprecated the study of ancient styles, but he himself thought there was nothing better than that. There was something defective in science that did not express art as well.

**Mr. E. Lawrence Hall** said he would very much like to hear Mr. Adams's criticisms of modern architecture answered by an architect who had been responsible for some of the buildings to which Mr. Adams took exception. As to the old builders being so much better acquainted with natural forces and laws of gravity than we were, he did not think that was the case ; it was not so much science in their case as trial and error. Mr. Adams had ruled out beam construction as not being a proper method of construction, but that would rule out a many-storeyed building. How could a building of six or seven storeys be got up without beam construction ? The weight would be enormous if every storey was vaulted, and it seemed that every storey would be a little smaller than the one below it, and that would give rather a curious building in a high structure. He would also like to know how Mr. Adams managed the lights in his factory building. It looked like bent glass between concrete ribs, and he thought that would give rise to some difficulty. It seemed to want some practical working out. The factory was 90 ft. wide and divided into 30 ft. bays. This was a very light construction in steel work, but it would be comparatively heavy for vaulted wotk.

### THE LECTURER'S REPLY.

**Mr. Maurice B. Adams,** the author's father, replied to the discussion. He said the difficulty mentioned of building on two or three floors had effectively been overcome, and there was no bent glass in the factory, as had been suggested. With regard to vaulted structures Sir Thomas Jackson had been called upon to report to the Russian Government with regard to some of the domes in Russia. He found a vast number of domes more or less damaged by earthquake, and many of the domes had been standing for centuries without part of their supports—they were so enormously strong that they were able to stand without some of their legs. Throughout the war the experience of the Royal Artillery and other branches of the Service was that the concrete buildings stood the shock of all the heavy commotion of firing far better than anything else. If an attempt were made to knock a hole through some of the vaults which his son had built it would be found a hard thing to do, and after they had been in existence a few years they would get harder and harder. One of the objections to this form of construction was that the building could not be altered once it was erected because it was so enormously strong. Whatever the faults of Mr. Adams, junior—and all pioneers made mistakes—he had tried to take the material on its merits, and had tried to do something with concrete which he did not think anybody else had tried to do.

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## *THE SOCIETY OF ARCHITECTS.*

# WAREHOUSE DESIGN.

### By HENRY ADAMS, M.S.A., M.Inst.C.E., Etc.

In the course of a paper on " The Need for More Care in Warehouse Design," read before the Society of Architects recently, Mr. Henry Adams, M.S.A., M.Inst.C.E., M.I.Mech.E., etc., referring to the difficulties encountered in connection with foundations in riverside districts, said that in many cases the foundations had to be supported on the light soil above, as it would not pay to go down to the firm gravel, and then a reinforced concrete raft was the only feasible plan. The introduction of reinforced concrete was still sufficiently recent, he said, to be called a new method of construction, and there were many pitfalls to be guarded against. At first even experts did not know what contingencies they had to meet, and shear stresses were ignored. They also failed to appreciate the importance of grading their aggregate so as to get a denser concrete. The use of coke breeze was permitted, and this was unfortunately emphasised by the British Fire Prevention Committee showing that a breeze concrete floor did not collapse so soon as one made with flint gravel or limestone.

He had had many instances before him of cases of failure of reinforced concrete buildings, but the causes might be summed up under two heads, viz., ignorant designing and careless workmanship, and these were often associated. In one case the reinforcement of the floor beams did not reach to the ends, so that they simply sheared through the concrete when the load came on. In another case, the floor fell directly the supports were removed, because the cement was deficient in quality and quantity. A factory with very heavy loads was constructed with a substantial basement, but owing to the shear members being displaced during construction, dangerous cracks developed, and very expensive brickwork supports had to be provided. At the same place some of the pillar reinforcement and even the pillars themselves were over each other on the adjacent floors, so that undue stresses were caused, and the whole job was unsatisfactory. In another case of collapse the reinforcing rods of the floor slab had been cut through to allow of circular openings being made, and no trimming around the hole was provided to carry the load, the adjoining steel rods being only sufficient for carrying the portion of slab covering them. Another case, where a new factory collapsed with fatal results before the erection was completed, demonstrated almost every possible fault. The concrete span roof had no extra reinforcement at the part where the maximum stress occurred, and the roof principals were not connected to the wall piers, but only rested on them. The reinforcement in the latter stopped short 2 ft. 6 in. from the eaves. Many mistakes were made in calculating the sectional area of the reinforcement, and in the wide foundation to the walls it was shown at the upper side instead of the lower. Also, the work continued through frosty weather without any precautions; the foremen and men were changed during that time; the aggregate for the concrete was obtained on the site, and not washed; part of the "sand" consisted of the dust from broken bricks; the brand of cement was changed during the course of the work—after the collapse there were places where loose pebbles could be taken out by handfuls, showing absence of cement and proper mixing; at other parts the concrete had been frost-bitten and was as soft as if it had just been mixed, although, perhaps, three months old; ends of the reinforcing rods were sticking out at the sides of the beams; and some of the pillars were bent and cut out of upright.

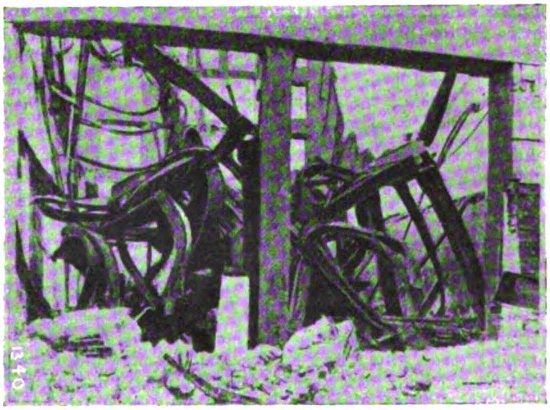

Fig. 1. A Building at San Francisco showing the effect of Fire on Rolled Steel Joist Framework

The Reinforced Concrete Regulations of the London County Council laid down the rules of designing with sufficient clearness and fullness to enable a safe design to be prepared, but it was not sufficient unless the greatest care was taken to supervise the execution of the work. As a fire-resisting material, reinforced concrete was only approached by good brickwork, but it had the advantage over the latter in being capable of being used alone for floors, staircases, etc. In the great fire at San Francisco, its superiority was most notable, and equally so in the great explosions at

Silvertown. Reinforced concrete had another distinct advantage, in that any damage caused to it was generally confined to that particular spot. For example, at Port Talbot a 4,000-ton steamer ran into a reinforced concrete jetty and buried its stem in the front portion, but the damage was purely local, and the cracking of the deck did not extend for more than 3 ft. beyond the point where the ship's stem came to rest.

Reinforced concrete was particularly well adapted to warehouse construction provided it was used intelligently. It was naturally a plain-looking material, but by dividing up the exteriors into piers and panels, with a plinth, frieze, cornice and blocking course, it could be made quite sightly. It required no periodical painting, was not affected by the weather, and had not been in existence long enough to enable the duration of its life to be determined. The usual construction inside consisted of pillars, 18 ft. to 20 ft. centre to centre, with main beams across them in one direction, and cross beams, 5 ft. to 6 ft. centres, in the other direction, and a continuous floor slab, 4½ in. to 6 in. thick, with angle brackets on the pillars, and fillets at all the junctions with beams and slabs. The concrete was usually a mixture of one part cement, two sand, and four larger aggregate, and was allowed to be stressed to 600 lbs. per square inch compression under working conditions, the steel at the same time being allowed 16,000 lbs. per square inch tension. The larger aggregate might be of almost any size for mass concrete, but for reinforced concrete it should vary from ¼-inch to a maximum of ¾-inch, and the sand might vary between $\frac{1}{50}$-inch and ¼-inch. The cement should be slow setting and always comply with the British Standard Specification. Hard broken brick was suitable for use, except Fletton bricks, which contained sulphur and might cause expansion and disruption.

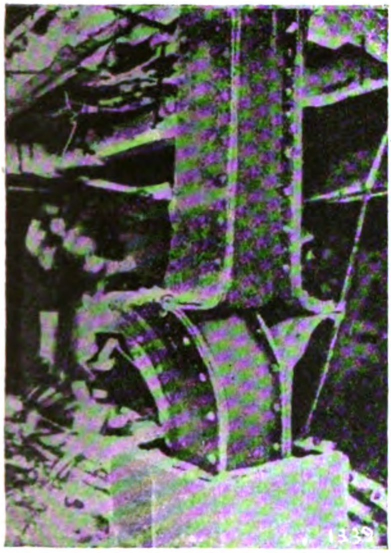

**Fig. 2.** Failure of Terra Cotta Casing to Steel Stanchion in a Fire, allowing the Stanchion to Buckle.

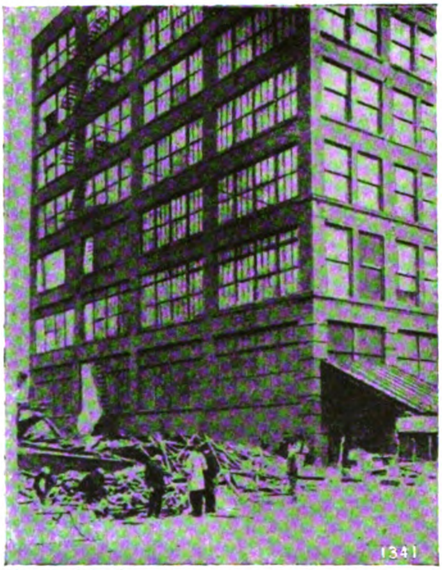

Fig. 3. Warehouse with Metal Window Frames and Wired Glass Windows undamaged after Fire.

The maximum of economy was obtained when the materials were stressed up to their working limit under full load, the reinforcement then being 0·675 per cent. When the floor slab was continuous over several spans, the outer bay should be about three-fourths of the width of the others for equal thickness, and if proper provision were made for the reversal of stress over the supports the safe load per foot super might be taken as one and a half times what it would be on a portion of floor taken as a single beam supported at the ends.

For warehouse construction, a mixture of 1 : 4 was sufficient to prevent dampness without the addition of any damp-course. In cavity walls the outer wall was merely a protection for the inner wall, which carried the weight of the floors, etc. He thought that inclined shear stirrups were better than vertical shear stirrups. It was absolutely essential that the aggregate used in the manufacture of concrete should be graded to various sizes.

In the discussion which followed the reading of the paper, **Sir Charles Ruthen**, O.B.E., F.R.I.B.A., said he was convinced that reinforced concrete would be the construction of the future. Providing that the design was good and the aggregate properly graded, no better system could be evolved, and he did not know what architects would do without reinforced concrete when they had to work on a bad site, such as a foreshore.

Replying to points raised in the discussion, **Professor Adams** said that the steel in continuous beams could be arranged in different ways. In a poured continuous beam, the stresses reversed at approximately one-fourth of the span from the supports, so that if it was required for tension at the centre of the bottom part of the beam the steel should be in the top of the beam at the ends; in the case of a foundation pressing upwards upon a beam and slab arrangement the stresses were reversed, and the steel should be reversed in position. He did not think that the London County Council valued continuous girders at their full worth. In continuous beams, a greater bending movement than would theoretically occur had to be allowed for in the centre in order to cover any error that might occur in the designing of the ends. Beams would act according to the reinforcement provided, and if negative reinforcement was not provided over the supports they would act simply as supported beams and not as continuous beams. They would only become continuous beams to the extent to which negative bending movements were provided for.

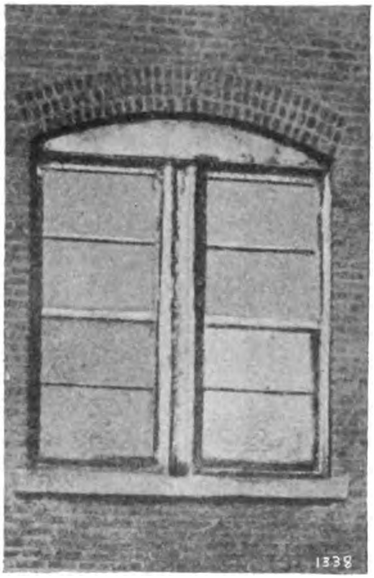

Fig. 4. Wired Glass Window in same Building after Fire.

The economic section of beams when the steel and concrete were stressed to the full limit depended upon the form-work, and if the form-work yielded an alteration in the stresses would result. There were a large number of contingencies which might affect the stresses to a certain extent, and the factor of safety was to provide for these unknown contingencies. In steelwork the factor of safety might be four, but actually it was only two, because it should be calculated upon the elastic limit and not upon the ultimate stresses.

The lecturer agreed with the London County Council that brackets were desirable, and thought they should be provided in every case; fillets also were desirable against the beams and the pillars. Enough centreing must be provided to support the weight of the concrete, and the steel reinforcement could not be relied upon to do any of its work until the mass had set; therefore, the whole of the weight must be taken by the form-work so that the reinforcement could set in the exact position in the beam in which it was required.

With regard to piling, concrete had proved to be the best and most economical material, and it was not a matter of choosing between concrete and timber, but simply of choosing the best concrete. Generally speaking, pre-cast concrete piles were preferred.

We are indebted to Professor Adams for the kind loan of the illustrations accompanying this abstract.

# PRACTICAL NOTES ON PROBLEMS IN CONCRETE CONSTRUCTION

By OSCAR FABER, D.Sc., M.Inst.C.E., etc.

*Under this heading we propose to publish information which should be of special value to contractors, supervisors, clerks of works, etc., dealing with the actual execution of concrete work. This information, wherever possible, will be based on practical experience and will deal with all aspects of concrete work.—ED.*

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## WHEN TO STRIKE MOULDS.

*(Continued from January issue.)*

HAVING now shown how much hangs on settling this question accurately, we may proceed to give governing considerations from which any given case may be determined.

The things which mainly affect the question are three :—

(1) What factor of safety was used in the design ?

(2) What ratio exists between the load of the structure itself and the total load to be carried ?

(3) The average temperature between concreting and striking moulds.

Let us consider these things first of all in a general way. It is clear if the factor of safety is great, the concrete will be strong enough to carry its load safely at an earlier period than when only a small margin exists. Similarly, a structure in which the whole load is due to the weight of the structure itself is obviously fully stressed as soon as the moulds are struck, while one in which its own weight is only, say, a quarter of the total weight is only stressed to one-quarter the stress for which it was designed, and therefore is obviously strong enough to carry these low stresses at a much earlier stage than the case previously mentioned.

Thus, suppose, for example, a structure is designed for—

| | | lb. per sq. ft. |
|---|---|---|
| Live load | .. .. | 200 |
| Own weight | .. .. | 100 |
| | Total .. | 300 |

Suppose, further, that working stresses are produced by the whole load of 600 lb./in.$^2$ Then clearly the own weight of the structure only stresses the concrete to 200 lb./in.$^2$ If we allow a factor of safety of $2\frac{2}{3}$, we must not strike moulds till the concrete has a strength of $2\frac{2}{3} \times 200 = 533$ lb. per sq. in.

Now an average concrete in average temperature conditions which gives a strength of, say, 2,400 lb./in.$^2$ in 4 months and 1,600 lb./in.$^2$ in 4 weeks will have a strength of 800 lb./in.$^2$ in as little as a week or even less, and this would therefore be a safe time to strike.

On the other hand, if the whole loan is the weight of the structure itself, and this stresses the concrete to 600, thed to get a factor of safety of $2\frac{2}{3}$ we ought to wait, say, four weeks in the case of the concrete just mentioned.

The example serves, however, to show clearly how important an influence this question of ratio of own load to total load has on the safe time for striking moulds. Four weeks to one week is a big jump, and yet the week is as safe in the one case as a month in the other.

The remaining consideration, which is equally important, is temperature.

It is a fact that concrete sets very slowly at low temperatures, so that in a week at 40° F. the concrete may be no stronger than in three days at 60° F., or even less at 80° F. It is clear that we must therefore allow much longer time in cold weather than in warm weather. The scientific way of taking this into account is, of course, to have strength curves for concrete at different temperatures, from which we can see how long a period at the actual temperature of the job is equivalent in hardening time to the time at average temperature (always taken at 60° F.) calculated by the method given before. In other words, say we want a strength of 800 lb./in.$^2$ before we can strike, we get this in a week, say, at 60° F., our curve will tell us how long must elapse before we get this at 40° F., probably two weeks.

Such a curve is given in *Fig.* 1 and may be used as has been explained, and as will be shown by examples. This curve may be taken as a fair average, but it must be remembered that concretes vary. If the cement is not of the very best (say, less than 50 per cent. above

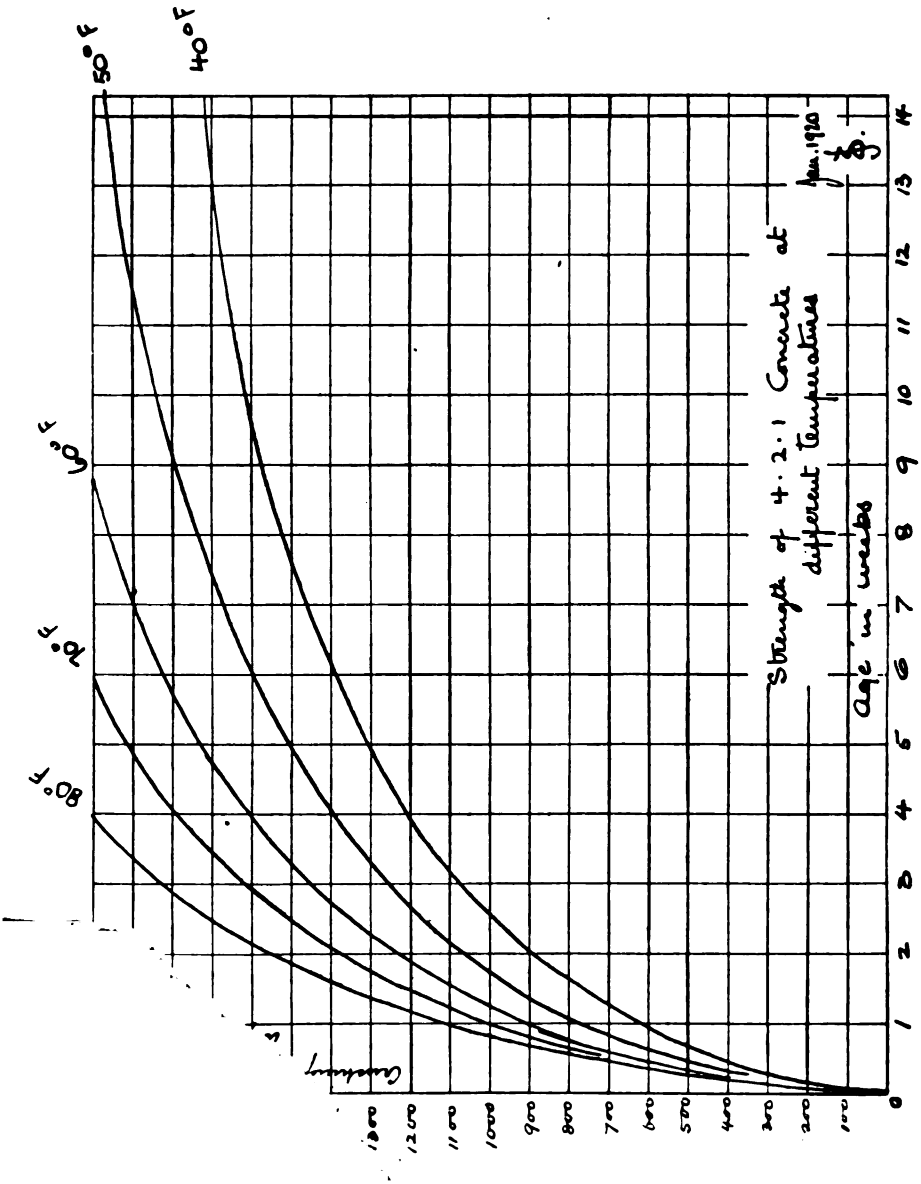


Fig. 1.

te or
ower
nes

Before giving examples of how the thing may be treated scientifically, a word as to the taking of temperatures.

(1) Be sure the thermometer is fairly placed. How often have I seen it screwed against the office wall, with a roaring coke stove inside the office.

(2) Take the temperatures at definite

times each day. The best arrangement is to take them—

(a) when the job starts (say, 8 a.m.);

(b) at noon;

(c) when the job closes (say, 5 a.m.).

As a rule, the first and last will give lower readings than at noon. A mean of the three is a fair mean for the 24 hours.

(3) Keep a record daily in a systematic manner, also recording carefully when different parts of the structure were concreted. For this purpose a set of drawings specially prepared is most useful on which each day's concreting can be marked off and dated.

In any particular case, say concreting was done on January 4th, and the record of temperatures is thus :—

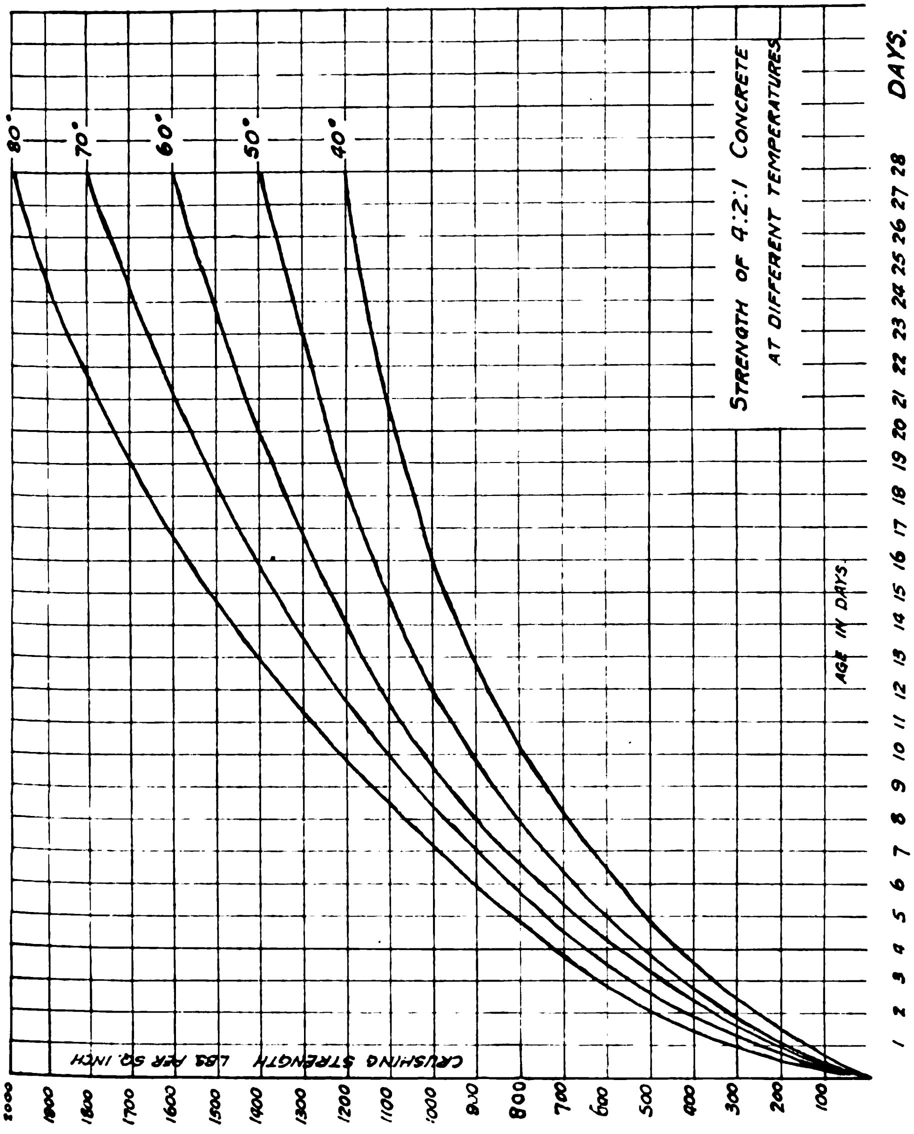


FIG. 2.

| | | |
|---|---|---|
| Jan. 4 .. | .. 45 | |
| 5 .. | .. 47 | |
| 6 .. | .. 50 | |
| 7 .. | .. — | (Sunday) |
| 8 .. | .. 42 | |
| 9 .. | .. 42 | |
| 10 .. | .. 46 | |
| 11 .. | .. 43 | |
| 12 .. | .. 43 | |
| 13 .. | .. 40 | |
| 14 .. | .. — | (Sunday) |
| 15 .. | .. 38 | |
| 16 .. | .. 50 | |
| 17 .. | .. 42 | |
| | 12)528 | |
| Mean .. | 44 | |

Suppose now, for this job, the ratio of own weight to total weight is as one to three, and stresses of 600 have been designed for. Then, as before, the due to own weight is 200, and with a factor of $2\frac{2}{3}$, we want a concrete strength of 533 before we can safely strike.

Now reference to our curve shows us we get this at 44° at about five days. The curve is not given for 44°, but it can be seen where it would lie if given.

Now this is the scientific way of doing it, and it is as well that the principle should be understood. For practical purposes it is generally sufficient to refer to the following tables, which have been calculated on the principles given above.

A word should be said on the factor of safety, which we are taking at $2\frac{2}{3}$ for this purpose. Now the usual factor, for design, is 4, but this applies to the strength of concrete at four months. The L.C.C. allow 600 lb./in.$^2$ on concrete having a strength of 2,400 lb./in.$^2$ at four months and 1,600 lb./in.$^2$ at one month. Clearly, then, while the factor is 4 at four months, it is only $\frac{1{,}600}{600} = 2\frac{2}{3}$ at one month, and as structures are often loaded at one month, this appears to be a safe value for this purpose.

### Table I.

Ratio of $\frac{\text{own load}}{\text{total load}} = \frac{1}{4}$

(This is often about the figure for warehouse and factory floors.)

Stress caused by own load $= \frac{600}{4} = 150$

Centering not to be struck till a strength of $2\frac{2}{3} \times 150 = 400$ lb./in.$^2$ is obtained. This is given at following periods :—

| Average Temperature. | Safe time to Strike Moulds. days. |
|---|---|
| 40° F. | 3 |
| 45 | ,, |
| 50 | 2½ |
| 55 | ,, |
| 60 | 2 |
| 65 | ,, |
| 70 | 1½ |
| 75 | ,, |
| 80 | 1¼ |

Probably a little longer could be allowed without extravagance.

### Table II.

Ratio of $\frac{\text{own load}}{\text{total load}} = \frac{1}{2}$

(This is often about the figure for office floors, public buildings, etc.)

Stress caused by own load $= \frac{600}{2} = 300$

Centering not to be struck till a strength of $2\frac{2}{3} \times 300 = 800$ lb./in.$^2$ is obtained. This is given at the following periods :—

| Average Temperature. | Safe time to Strike Moulds. days. |
|---|---|
| 40° F. | 12 |
| 45 | 10 |
| 50 | 8 |
| 55 | 6 |
| 60 | 5 |
| 65 | ,, |
| 70 | 4½ |
| 75 | ,, |
| 80 | 4 |

### Table III.

Ratio of $\frac{\text{own load}}{\text{total load}} = \frac{2}{3}$

(Often the case for roof flats, domes, long-span foot-bridges and concrete structures to carry lightest loads only.)

Stress caused by own load $= 600 \times \frac{2}{3} = 400$. Centering not to be struck till a strength of $2\frac{2}{3} \times 400 = 1{,}066$ lb./in.$^2$ is obtained. This is given at following periods :—

| Average Temperature. | Safe time to Strike Moulds. days. |
|---|---|
| 40° F. | 21 |
| 45 | 17 |
| 50 | 14 |
| 55 | 12 |
| 60 | 10½ |
| 65 | 9 |
| 70 | 8 |
| 75 | 7 |
| 80 | 6½ |

Now these tables are clearly easy to use in practice. A clerk of works can secure from the designer a statement of which table fits any particular job best.

As to the short periods, nothing need be said except that it may open the eyes of some people to the fact that scientific treatment sometimes pays. As to the long periods, these are often much reduced in practice, but even then the table is useful, because it warns the clerk of works when he is treading on dangerous ground. A factor of safety of less than four is then being adopted, at least temporarily, and it is generally under these very conditions of striking moulds that failures have sometimes occurred.

It will be noticed that the longest periods occur at low temperatures, particularly in Table III.: that is when the own load is a high proportion of the total load. Now very often the low temperature can't be helped. But being on Table III. can. In other words, if the designer will design for a load not less than twice the own load (even though the actual live load expected may not quite justify this) he can keep on Table II. and may save money and time in actual execution.

One other word. The times given have all assumed the structure remains unloaded, after striking, till the concrete has acquired a strength of 1,600 or thereabouts. Now often in buildings this cannot be done, as bricks, etc., have to be placed in small quantities on the floors. In that case, a few props must be placed under the floors after striking, or else the floors left unloaded for a while and then loaded to a load less than that designed for, until the strength of 1,600 has been secured.

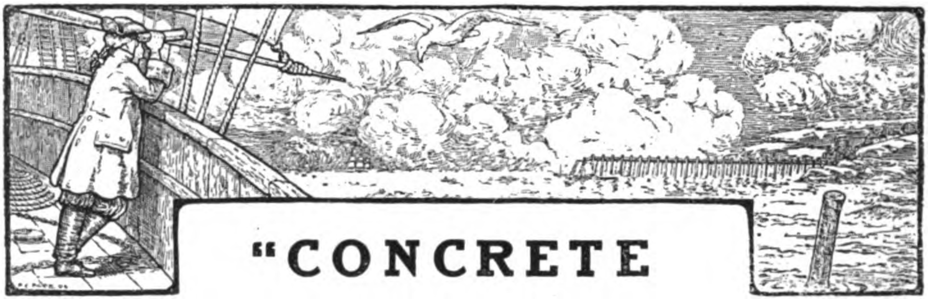
The foregoing has applied to striking centering to soffits.

Clearly beam sides, column sides, and wall centering may be removed without affecting the stresses in the concrete at all. In these cases a period varying from a single day at about 80° F. to a week at 40° F. will generally suffice.

## MEMORANDUM.

**Signalling Concrete Mixer by Lights.**—In a recent number of *Engineering News Record* Mr. E. K. Borchard relates that " on a recent concreting job it was necessary to move delivery chutes frequently, which necessitated holding up the mixture and also the delivery from the discharge hopper at top of the hoist tower. Bells were first used as a means of signalling, but were sometimes not heard or were misunderstood. Signal lights connected in series proved much better than bells and were foolproof. When the concreting gang wanted to shift chutes they turned out their light, which in turn automatically extinguished the lights at the tower head and the mixer. Instructions were given not to mix or send down concrete unless the lights burned, so this stopped the supply.

When the work was ready to proceed again, the concreting gang turned on their light, which lighted the other two also. By having the light at the end of the chute the foreman or any of the gang could see at a glance whether concrete was coming, and there was no uncertainty concerning whether the signal had or had not been given. The lights connected in this way burn dimly unless lower-voltage lamps are used.



# "CONCRETE SHIPBUILDING"

*We regret that owing to lack of space we have had to hold over our Notes on Concrete Shipbuilding.—ED.*

## REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

### CHAPTER VIII.

### TESTS OF CONCRETE VESSELS.

Few critical tests have been made of concrete vessels, though this is not so important as might be supposed, as the severe conditions encountered in launching any vessel are amply sufficient to ensure that those made of concrete will be able to resist any future forces they may be expected to encounter successfully.

The *Beton I.* constructed by the Porsgrund Cementsöperi, was tested by loading with concrete blocks disposed so as to make the load per foot run amidships twice that at the ends, the full load amounting to 182 tons. A depression of 0.40 in. fore and aft was observed, 0·12 being due to the loading of the deck, leaving 0·28 in., which compared admirably with the calculated figure 0·26 in., considering the unavoidable uncertainty in fixing the modulus of elasticity, which was taken as 890 tons per square inch. The bottom beam showed a total elevation of 0·08 in., while the ribs showed 0·24 in. bending inwards, and 0·20 in. bending outwards, when the deck was loaded, which are insignificant deformations. The calculated stresses corresponding to the loading are as follows :—

Pressure on deck, 427 lb. per sq. in.
Shearing in the skin, 120 lb. per sq. in.
Tension in bottom, 10,000 lb. per sq. in.

The surface was scrutinised under a magnifying glass at the point of maximum shear and at all accessible places, and no sign of cracking or failure was anywhere observed.

When the loading was removed, all the strains proved to be elastic except 0·04 in. depression which remained fore and aft. Probably this was only due to inertia in the material, no permanent set being produced.

Some moist spots appeared in the sides while the loading proceeded, but were found to disappear before the loading was completed, showing that further setting took place in water wherever the concrete was left somewhat porous.

" At the time of the blowing up of the cofferdam behind which the pontoons were built, the surface of the water in the entrance did not allow the water to pour in from the sea until the tide rose. The stream which broke over the dam at high tide cut an increasing channel in the earth, resulting in a strong inrushing current sufficient to make the barges part from their moorings and circle about the basin. In so doing one of them struck a fender pile and broke it at a point about 20 ft. below the butt, where its diameter was about 12 in. The barge groaned under the impact, and one of the end timbers was sheared off, dragging its anchor bolts through the concrete and causing it to crack. This damage was above the water line. In other respects the pontoon was uninjured. The two pontoons collided once in their course round the basin, but this did no damage to either.

The testing of materials for reinforced concrete ships is one of extreme importance, and the Concrete Institute's report on this subject should be carefully studied. The whole of this report is applicable to shipwork, except that the maximum size of the coarse material requires, in the opinion of the author, to be reduced to ⅜ in.

Additional tests are desirable as to the impermeability of concrete and also as to resistance to shock.

Although a large amount of experimenting and testing on reinforced concrete has been carried out, much remains unknown when compared with ascertained data from research work undertaken on other materials.

The necessity for checking the strength of the concrete immediately after placing in position is very important. Much work remains to be done before this accelerated ‘ ageing ” test can be considered to afford standardised data for guidance.

## CHAPTER IX.

### REPAIRS.

CONCRETE vessels have a marked advantage over others in the ease with which they may be repaired by relatively unskilled workmen and without the necessity of docking. The importance of this in the case of barges and of cargo boats in districts remote from ship-repairing yards can scarcely be over-estimated. In addition to this, concrete has so great a resistance to the forces which ordinarily cause damage to vessels that it has a high value in this respect.

When a concrete vessel is damaged it may be easily repaired by blocking the hole with a small timber shuttering, inserting, if necessary, a few reinforcing bars and filling the hole with a rich (1 : 1 : 2) or (1 · 1) concrete. It is important to take the same precaution in packing as in continuing the placing of concrete after a cessation of work, and it is usually desirable to chip and clear the fracture so as to secure adequate adhesion of the new concrete. The patch will be able to stand water pressure in a couple of days, or even less, and if desired the shuttering need not be removed before putting to sea again. Such a repair may even be carried out under water.

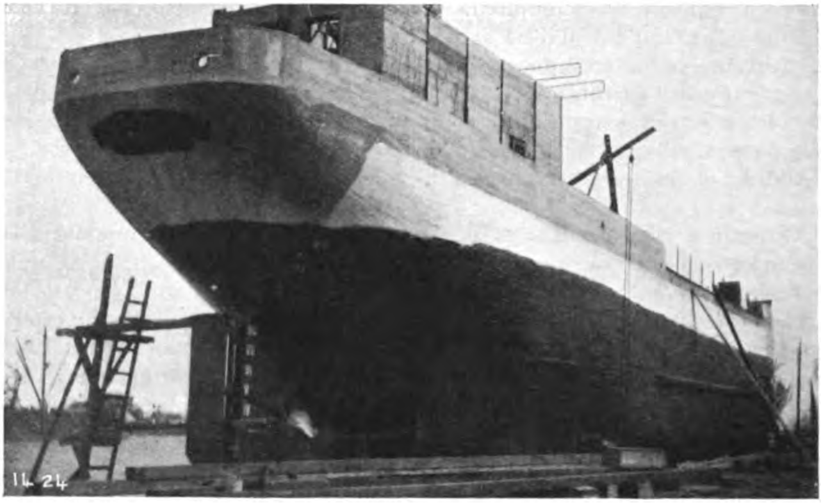
The actual time required for the patch to be sufficiently strong to be regarded as an integral part of the vessel depends on its size and position, but it is usually much shorter than the time required to reach port and complete the repair of a steel vessel.

## OTHER NOTES ON CONCRETE SHIPBUILDING.

**A New Barge Launched in Preston.**—A 1,000-ton concrete barge, *Cretemore*, built on the Ritchie system was launched last month in Preston. The vessel is 180 ft. long, 31 ft. beam, and 19 ft. deep, with an extreme o.w.l. draft of 15 ft. 3 in. She is designed for a speed of about 9 to 10 knots at sea. Three cargo holds are provided with a total capacity of 61,890 cu. ft. net, and the vessel is divided into five watertight compartments by means of four transverse bulkheads. She is to be employed in the Continental trade between one of the East Coast ports and those on the French and Belgian coast.

**A Concrete Motor Coaster in the Argentine.**—The accompanying illustration shows the concrete motor coaster *Don Alberto*, built in the Argentine Republic by

Messrs. Hume Bros., Buenos Aires. This motor coaster is of the following dimensions: Length, 131 ft.; beam, 21 ft.; depth, 15 ft.; loaded draft, 12 ft. She was built on the monolithic system, with a continuous outside mould, the inside mould being taken up in steps from one longitudinal stringer to another, making the horizontal joint in the middle of these stringers, which were about 3 ft. apart.



A CONCRETE MOTOR COASTER BUILT AT BUENOS AIRES.

The concrete aggregate was of fine crushed granite chips, well cleaned, and clean river sand of two grades was employed, an integral waterproofing paste being used to insure impermeability.

The thickness of the hull was 4 in. at the bottom, and 3 to 3½ in. at the sides, the usual form of frames being employed.

The ship is divided by means of four bulkheads, into two holds for cargo, engine room, and two trimming tanks which are in communication with the engine room pumps.

The motive power consists of a pair of engines of 100 h.p. semi-Diesel, by the August Meisse Corporation, burning a light fuel oil from Mexico, the Argentine oil not being suitable for these engines owing to its asphaltic base.

This boat was built during the war under great difficulties, owing to the impossibility of obtaining the materials required locally.

The ship was launched sideways from a cradle constructed from eucalyptus trunks, as no pine baulks were obtainable, and the native hardwoods are not suitable for this work. No difficulties were encountered once the ship was got moving, as the slope of the ways was 1 in 6. We are informed that this is the first seagoing vessel constructed in South America, although a good many barges have been constructed in Buenos Aires.

# NEW BOOKS

## AT HOME AND ABROAD.

***A short summary of some of the leading books which have appeared during the last few months.***

**Modern Roads. By H. Percy Boulnois, M.Inst. C.E., etc.**

London: Edward Arnold, Price 16/-

Mr. Boulnois is a well-known authority on roads, and this book comes at a time when the question of good roads is so prominently before the public. The author deals with the following subjects in an exhaustive and practical manner, viz. :—Traffic, Water-bound Macadamised Roads, Tar Treatment of Road Surfaces, Bituminous Roads, Bituminous Carpets, Waves and Corrugations, Paved Streets (including granite setts and wood blocks), Concrete Roads, and Slippery Streets. The chapter that mostly concerns us is the one on Concrete Roads, to which no less than 44 pages are devoted, giving details of various methods, and a specimen specification under which such work should be carried out. The objections which have been raised in connection with this form of highway, and how they should be overcome, are dealt with, and the author points out that if ordinary precautions and skill are used in construction these objections are negligible.

The book is well called *Modern Roads*, as it brings the whole subject up to date and should be read by anyone interested in the development and evolution of our roads, which is daily becoming more and more pressing. We are tempted to give the concluding words of this interesting and important volume, which are as follows :

"For many years past transportation has been bound like Andromeda to the rock of the railway, but to-day, Perseus, in the form of the self-propelled vehicle, has come to her aid, and by the assistance of 'Medusa's' head in the guise of good roads, will liberate her from her bonds, and transportation will again be free. It is for the highway engineer now to play his part in this liberation."

**Analysis of Statically Indeterminate Structures by the Slope Deflection Method. By W. M. Wilson, F. E. Richart and Camillo Weiss. Bulletin No. 108, Engineering Experiment Station, Urbana, Illinois.**

London: Chapman & Hall, Ltd. 218 pp. Price One Dollar.

*Contents.* — Derivation of Fundamental Equations — Determination of Stresses — Girders having Restrained Ends—Continuous Girders —Two-legged Rectangular Bent—Two-legged Trapezoidal Bents—Rectangular Frames—Moments in Frames—Three-legged Bent—Effect of Error in Assumptions—Numerical Problems—Conclusions.

This is a very useful addition to the series of bulletins published by the Engineering Experiment Station at Urbana, and it contains some interesting matter in connection with the analysis of the stresses in rectangular frames. The common use of such frames in engineering structures makes it highly desirable that the most convenient methods of finding the stresses should be developed, and as frames made up of rectangular elements are usually statically indeterminate the methods and formulæ presented by the authors should be carefully studied. The slope deflection method renders the physical conception of a problem easier than in the case where differentiation or integration is performed, and the general form of the fundamental equation is easily memorised. With the use of riveted connections in steel frames and the extensive development of monolithic reinforced concrete structures it often happens that statically indeterminate stresses cannot be avoided, and rational methods of design will do much to inspire confidence in the reliability and economy of such structures.

The matter is clearly written and indicates a thorough investigation of the problems by the authors which make the book a desirable one.

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

*In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.--ED.*

*Question.—A reinforced concrete jetty is beginning to form vertical cracks near the corners of some of the piles. What are these due to, and how can they be cured?—F.W.*

*Answer.*—The cracks referred to indicate that corrosion of the steel is taking place. This often happens to reinforced concrete work in sea water where no special precautions have been taken to guard against it. The protective action of the concrete depends on its alkaline qualities preventing carbonic acid from reaching the steel. The magnesium chloride in sea water replaces the calcium in the cement and gradually washes away the alkaline substances, after which corrosion proceeds. The cracks are caused by swelling of the steel owing to its oxidation, the oxide occupying a volume about twice that of the original bar, and clearly this expansion causes the concrete to be pushed off and forms the cracks referred to.

No kind of patchwork or surface treatment is any good, as the corrosion will continue apace and fresh cracks will form. The only thing any good is to strip away the concrete round the core of the pile—all the concrete outside the binding—and replace it with new. This involves fresh shuttering, and as the thickness will be small, a 2 to 1 sand cement mortar is probably best, as any stones would get caught up and leave voids. When complete, the surface of the pile should be protected from further action by tar applied hot, down to low-water mark. The tar rubs off under these conditions. This may be partly avoided by winding strips of canvas over it in a continuous spiral, and then a second tarring over this. The pile will never be the same pile as if precautions had been taken in the first place before it ever touched sea water, but the treatment suggested is probably all you can do now.

*Question.—A beam carries about 50 tons on 34 ft. span. What is the shallowest it can be made in reinforced concrete?—L.V.S.*

*Answer.*—No definite answer can be given. You do not say whether the beam is continuous, whether it is a T beam, if so what is the slab thickness, and many other things which matter.

Probably 24 in. deep is quite the minimum any experienced designer would like to adopt, and to carry the load you mention would need very heavy reinforcement top and bottom, and a wide beam.

It would be more economical to use a deeper beam, say about 4 ft. deep, but you ask for the minimum.

With a shallow beam, the deflection will be appreciable, and the columns will need designing for a considerable eccentric stress.

## MEMORANDUM

**Travelling Cranes of Reinforced Concrete.**—A French company has developed a travelling crane of reinforced concrete. The crane, as described in *Le Génie Civil* has a capacity of 6,600 lb. and a span of 32·8 ft. The rolling gear is removable, and so attached that it can be adjusted to take care of any warping of the crane. The concrete used is made of 2·3 bbl. of cement to 1·18 cu. yd. of gravel and 0·52 cu. yd. of sand, a mixture which develops a crushing strength of about 780 lb. per sq. in., and a bond strength with the reinforcing of about 80 lb. To obtain a proper factor of safety, the maximum fibre stress in the concrete of compression members is limited to 498 lb. per sq. in. even under the most favourable conditions.

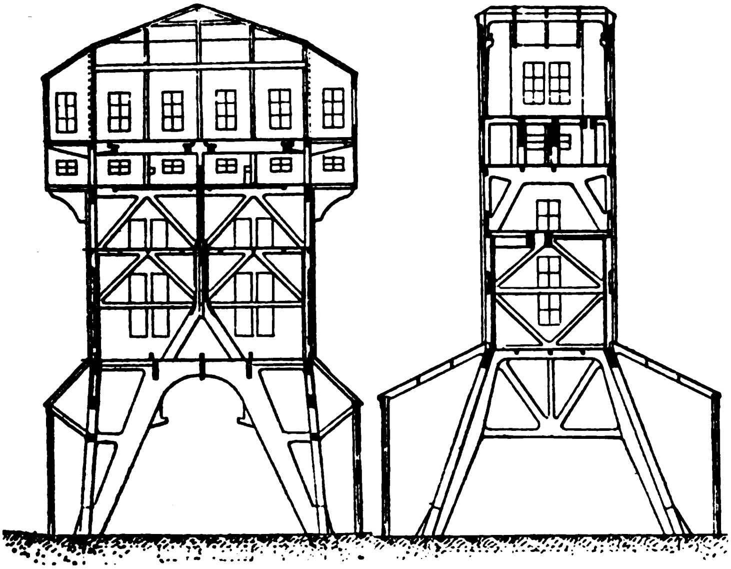
# THE FOREIGN PRESS.

*The following are abstracts taken from the foreign Press relating to concrete construction.—ED.*

**Mineheads of Reinforced Concrete at Camphausen, near Sarrebruck.**—It is safe to predict that the construction of mineheads of reinforced concrete is one of the simplest and surest means of reconstructing the coal mines in the devastated areas in northern France.

One example at Camphausen, near Sarrebruck, built in 1912 by Carl Brandt, of Aix-la-Chapelle, has five storeys—(i.) Into which the shaft opens, 45 ft. high ; (ii.) an intermediate storey, 28 ft. high ; (iii.) the pulley floor, 16 ft. high ; (iv.) the axle foundations, 12 ft. high ; and (v.) the machine room, 35 ft. high, making a total height of 136 ft. The engine house has a floor area of 31 ft. by 57 ft., with two rooms each 12 ft. by 19 ft.

Each hauling engine is controlled by an electric motor and is capable of raising 160 tons per hour from a depth of 215 ft. (which will later be extended to 233 ft.). The Koepe pulley and the pulley are 20 ft. diameter.



VERTICAL SECTIONS OF THE REINFORCED CONCRETE MINEHEADS AT CAMPHAUSEN

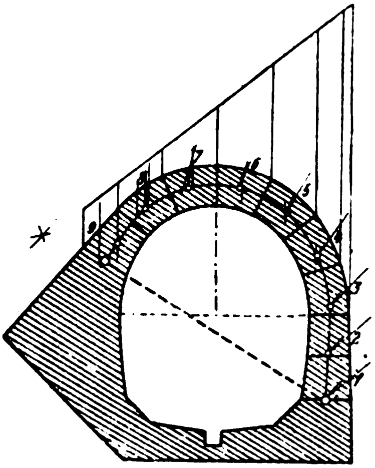
The foundations extend to 33 ft. below the surface, and the wood-work or framework is calculated to resist a tension equal to that produced by a cable loaded with 180 tons which breaks suddenly.

The structure is completely enclosed, and has the appearance of a tower whose pyramidal base is enclosed by the building of the shaft.

The advantages of this arrangement are : the concentration of the rope and pulley ; the increase of the arc of contact of the cable on the pulley ; and the substitution of vertical forces in place of the oblique ones which exist when the engines are in a separate structure.—*Le Génie Civil*, 1919, 409.

**Concrete in Tunnel Construction.**—It is only occasionally that reinforced concrete is used for the construction of railway tunnels, but two occasions arose on the Baghdad railway in which its use was invaluable.

The portion of the railway in which these tunnels occur is in the Taurus Mountains, and owing to the position of the track it was decided to build a tunnel of reinforced concrete and to cover this over with filled-in material, so that if any of the higher ground slipped it would not interfere with the trains.



The constructional work was partly carried out in the open and to a small extent by tunnelling and then building up the concrete structure to fit the tunnel.

As the work was carried out during the war and under considerable difficulties, it was decided not to adhere to the prescribed calculations, but to simplify the construction as far as possible.

The accompanying diagram shows the shape of the tunnel and its normal position relative to the surface. The thin, sloping line above it indicates the natural angle of repose of the ground material—viz., 39 degrees. The arch at the thickest part is 3 ft. 6 in., and the true moments are as follows :—

1. +16·0 mt.
2. + 6·9 ,,
3. − 0·6 ,,
4. − 8·7 ,,
5. − 9·9 ,,
6. + 8·2 mt.
7. + 9·4 ,,
8. + 3·3 ,,
9. −14·4 ,,
10. −24·6 ,,

The moment-zeros are near point 3, between points 5 and 6 and between points 8 and 9. At these points the steel reinforcement is bent to an angle of 45 degrees.—*Beton u Eisen.*

**Constructional Work in Indo-China.**—Constructional work in Indo-China is made particularly difficult by the nature of the soil and climate. The former is a plastic clay 6-18 ft. thick on a subsoil of mud of very irregular nature and indefinite thickness, though seldom less than 45 ft. The result is that whilst the clay is not sufficiently firm to act as a foundation, the subsoil is no better, and it is therefore necessary to use piles, though even these do not always give good results on account of the semi-fluid nature of the mud through which it is scarcely possible for the piles to penetrate. Probably the only safe foundation is a reinforced concrete raft mounted on a large number of reinforced concrete piles, but as this is generally prohibitive as to cost it is usual to employ either a raft or piles, but not both.

The superstructure is usually of granite for the ground floor and brickwork for the upper floors, but concrete is rapidly gaining favour. Some of the more recent public buildings are constructed of hollow blocks of reinforced concrete so as to be light and yet quite weatherproof. They must be strongly tied together in order to resist the very strong winds which prevail for several months at a stretch, and the joints must be so arranged as to keep out the violent rainstorms.

The floors are perferably of concrete, as this affords no shelter for the insects, which rapidly destroy all kinds of woodwork. The roofs should also be made of reinforced concrete, as tiles can seldom withstand the violence of wind and rain to which they are subjected, and when they are used it is most difficult to keep the interior of the building dry.

Hollow walls and roofs of reinforced concrete have the further advantage of permitting a current of air to circulate through them. In order to prevent damage by floods, the buildings are usually erected on a terrace or platform about 3 ft. thick. This may be made advantageously of hollow concrete blocks placed in rows 4 in. apart, the space between being filled with mass concrete, which also covers the blocks to a thickness of 3-4 in., forming a sort of monolithic hollow base.—*Le Ciment.*

**Concrete for Temporary Structures.**—It is often considered that for purely temporary work steel is preferable to concrete, as the latter is more difficult to dismantle. Concrete has, however, the following advantages over steelwork, which ought to be taken into consideration :—

*Economy.*—The present scarcity of steel not only maintains its cost at a very high level, but makes it difficult to obtain, and the delay in delivery often costs far more than is anticipated. The use of concrete effects a great reduction in the amount of metal used and the forms employed—bars—are such as can be rapidly and cheaply produced and readily transported.

*Durability.*—The greater durability of concrete is such that there can be no question of its superiority over iron or steel in this respect.

*Resistance to Fire.*—It has been shown that concrete is not only resistant to fire, but that it protects the reinforcement from expansion, and therefore does not create indirect damage such as pushing out the walls.

*Utility.*—Whilst concrete cannot be used with equal satisfaction for every kind of structural work, it is daily being used for novel purposes, and probably is capable of being employed for a greater number of purposes than any other single material.

*Simplicity.*—Concrete construction requires a certain amount of skill, but this is small relative to other materials.—*Le Génie Civil.*

**The Resistance of Concrete to Repeated Blows.**—Crushing and tensile strength tests are excellent for judging the comparative values of Portland cement and concrete for ordinary building purposes, but if these materials are to be used under conditions where they will be subjected to repeated blows or vibrations a third test should be added. Dr. Passow worked out an elaborate investigation in order to determine the value of a test in which a cube of the material of 2¾ in. sides is subjected to a large number of blows applied by a miniature pile-driver. At the same time he investigated the minimum height from which a weight must be dropped on a block of cement mortar or concrete in order to crack it at the first blow.

These experiments showed that resistance to blows depends more on the elasticity and toughness of the aggregate and on the hardening period than on the cement, provided enough cement is used to form a suitable binder. Curiously enough, whilst the crushing and tensile strengths increased with the age of the materials, its resistance to blows decreased.

There appears to be no definite relationship between either the crushing or tensile strength and the resistance of the material to a falling weight. Unfortunately, Dr. Passow's recent decease occurred before he was able to complete the whole of the tests he had in prospect.—*Beton und Eisen.*

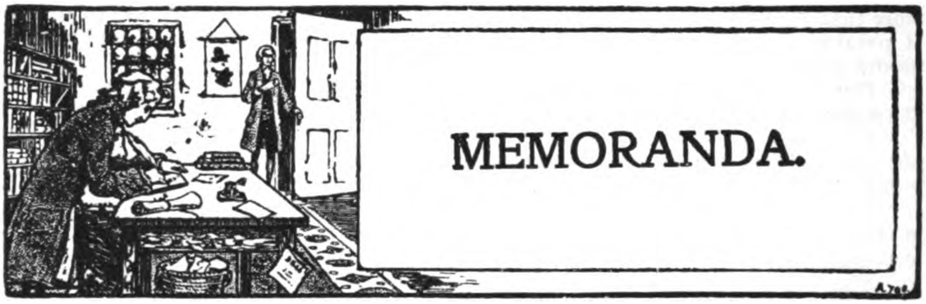
**Some Precautions Necessary in Concrete Work.**—Periodically there appears in the technical Press a statement that reinforced concrete is of uncertain durability because of the liability of the steel reinforcement to corrode. It has, however, been proved repeatedly that no corrosion occurs if the reinforcement is properly covered. If it is badly placed so that parts of it are exposed some corrosion must occur.

Considerable care and skill are required to place the reinforcement correctly, and this work should only be done by a skilled man. The proportion of water used must bear some relation to the composition of the concrete, yet the proportions employed in different standard specifications vary so greatly as almost to contradict the statement just made. Yet the quality of the concrete does not appear to suffer. Within very wide limits the proportion of water used is of small importance.

The amount of wood used in shuttering should be kept as small as possible (especially if it cannot be used over and over again). This is one of the chief problems of the contractor, and on it turns largely the amount of profit he will obtain on any given job. This subject deserves further investigation, as the problem is by no means an insolvable one. The construction of concrete work demands continuous supervision, as it is easy for bad work to be done.

Up to the present the design of concrete structures has been based on a limited number of assumptions or empirical rules, which include an excessive allowance for safety. So many buildings and other structures of concrete have now been in existence for so many years that where a saving is necessary it is often possible to reduce the factor of safety without running any serious risk.

Opponents of concrete constructions sometimes make much of the time lost between casting the concrete and that when it is ready for use. This objection is not really valid, for in all other forms of construction the materials have required considerable time to produce: steel work must be rolled, stone must be cut to shape, and bricks or terra cotta must be made, whilst the user of concrete deals with raw materials. —*Le Génie Civil.*



*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Cement Concrete Building Blocks.**—The following specification for cement concrete building blocks of various thicknesses has been approved by the Standardisation and Construction Committee of the Ministry of Health :—

*Cement.*—The cement is to be Portland, of slow setting quality, and is to comply with the requirements of the current specification of the British Engineering Standards Committee.

*Ballast Aggregates.*—The aggregates for blocks for outside walling, unless made of waterproofed clinker, are to be of granite, hard stone, or gravel broken to various sizes and with sufficient clean sharp sand to fill up interstices. The aggregate for blocks 4 in. thick shall pass a ¾-in. square mesh. The aggregate for blocks 3 in. thick shall pass a ¾-in. square mesh. The aggregate for blocks 2½ in. thick shall pass a ½-in. square mesh. The aggregate for blocks 2 in. thick shall pass a ½-in. square mesh. And for concrete less than 2 in. thick shall pass a ½-in. square mesh.

*Composition.*—The concrete for blocks of various thicknesses is to be composed by measure as follows :—4-in. thick blocks, 6 of aggregate to 1 of cement ; 3-in. blocks 5 to 1 ; 2½-in. blocks, 4 to 1 ; 2-in. and less, 4 to 1.

*Frogs.*—Blocks of ballast concrete may be made with frogs, the minimum thickness in a 4-in. block being 2½ in., and in a 3-in. block 2 in.

*Clinker.*—The concrete for blocks made of clinker shall be composed as follows :—Three inches thick and upwards, 6 of clinker and sand to 1 of cement ; under 3 in. thick, 4 of clinker and sand to 1 of cement ; a proportion of sand, not less than 5 per cent. and not more than 10 per cent., should be added.

*Composition.*—The clinker must be dense, vitreous, free from organic and combustible matter, and crushed to pass a ½-in. square mesh. All clinker to be well washed and screened before use.

*Sizes.*—Blocks made of clinker concrete should not exceed 18 in. by 9 in. for 4-in. and 3-in. thicknesses, and 24 in. by 9 in. for 2½-in. and 2-in. thicknesses.

*Waterproof Face.*—Blocks made of clinker concrete, if used for external work, shall have all faces and edges, exposed on the outer face of the wall, cast weathertight with a waterproofing composition.

*Mixing.*—All materials are to be accurately measured. The aggregate and the cement are to be mixed together dry until the mass is uniformly coloured with the cement.

*Water.*—Sufficient water is to be used during the process of manufacture to ensure the thorough setting of the cement throughout the entire thickness of the block.

*Age.*—No blocks are to be used for building until they have been properly matured.

*External Walls.*—All external walls must be built with two thicknesses of blocks properly tied together, with a cavity between of not less than two inches.

All blocks to be made of their full thickness in one operation.—*Housing.*

**Whitby Harbour Improvement.**—An interesting paper was read at the ordinary meeting of the Institution of Civil Engineers, on January 13th, by Mr. James Mitchell, M.Inst.C.E. The author referred to the former rank of Whitby as a port and the reasons for the loss of that rank. He then gave a description of the new works, which include two new sea piers, a new fish-quay with deep water alongside, a new entrance channel and general deepening of the harbour, and reasons were given for the expectation that Whitby will ultimately become a first-class fishing-port.

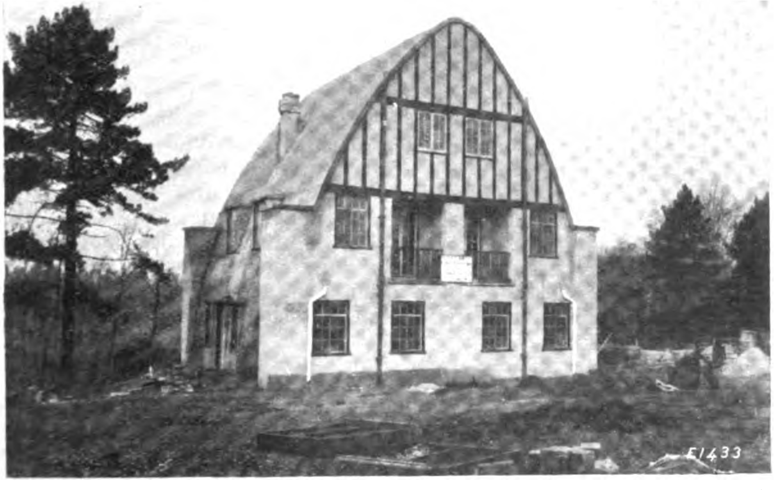
The piers are monolithic concrete structures, carried to a level of 7½ ft. above H.W.O.S.T., and surmounted by timberwork trestles, on which roadways are carried at a level of 22 ft. above H.W.O.S.T. They are founded throughout on alum shale rock, at depths ranging from 2 ft. to 12 ft. below L.W.O.S.T. The timber trestle-work, as originally designed, was intended to serve as staging, on which would be carried the railways, cranes, etc., required for construction, the lower portion of it being thereafter encased in concrete, so as to form part of the permanent structure. The contractors, however, in view of the exposure of the site, and the difficulty of driving piles in the shale rock so as to withstand the sea, proposed to adopt a novel type of locomotive stages, which would travel on the sea-bottom and carry cranes, divers'platforms, etc. This proposal was agreed to, the timber piles being dispensed with, and their place taken by uprights embedded for a length of 7 ft. in the concrete structure. A description of these stages is given, together with their method of operation, and speed of travelling. The difficulties met with in preparing the foundations, the type of concrete castings, and methods of concreting are described. Attention is drawn to various difficulties met with in the diving work, and to the influence of the quality of the concrete in minimising loss of concrete and concrete casing during construction. These works will be further dealt with in a future issue.

**Concrete Huts for the Arctic.**—Fifty concrete huts are to be erected this year in the Prestoff Islands by the American Government, as it has been found that the snow houses now used by the Esquimaux do not stand up under the winds that sweep off the Behring Sea.

**Concrete Lawn Benches.**—Some novel concrete lawn benches have been made at Mapleton School at Boulder, Colorado. The benches are of mass concrete and have an artistic cobble stone finish. These benches have a curve, and each measures 19 ft. in length and 30 in. front to back at base. The seat is 16 in. high, 16 in. deep with arms 10 in. high and 8 in. thick. The entire back is 3 ft. high, and the thickness of the back is 10 in., while the slope of back is 4 in. The foundations are 12 in. deep, and the seats appear to rise out of and rest upon a little rise of ground and to form a part of it.

## HOUSING NOTES.

**Cottages at Hertford.**—In a recent issue we gave some particulars of concrete cottages which were being erected at Hertford on the "Cat-ar" system. The accompanying illustration shows a pair of the cottages completed.



A Pair of Cottages at Hertford on the "Cat-ar" System.

**Concrete Houses at Braintree.**—The Unit Construction Co., Ltd., has secured a contract for the construction of 24 houses for the Braintree Urban District Council, as follows :—Type A, £1,800 per pair ; type B, £1,780 per pair ; type C, £1,821 per pair.

**North Sheen.**—The Richmond Council has accepted a tender of £6,156 for the erection of seven concrete cottages at North Sheen.

**Leeds.**—An extensive scheme for the erection of concrete houses will shortly be put in hand by the Leeds City Council. Part of the scheme comprises 800 houses to be erected at Meanwood by Messrs. Wm. Airey & Son. These houses will be built on what is known as the duo system. The walls will be constructed of slabs of concrete of suitable size with an air space between. Adjacent to the site is a large quarry which will be taken over by Messrs. Airey for the purposes of manufacturing material on the site ; thus economies in transport will be effected.

**Hendon.**—The Hendon District Council proposes to build 244 concrete houses on the Brent Hill Farm site.

**Acton.**—Acton has applied for sanction to borrow £28,175 to prepare land around its northern playing fields and the " Selfridge " concrete bungalows.

**Concrete Houses for Manchester.**—The Manchester Housing Committee, after hearing the report of the delegates who recently paid a visit of inspection to concrete houses in the South of England, passed an approving verdict on the principle of building by concrete, and decided to invite tenders for 500 concrete houses. The tenders have been asked for on the basis of costs already supplied by contractors.

**Bangor.**—The Bangor City Council have decided to purchase concrete block-making plant at a cost of £237 10s., and to proceed with the erection of houses by direct labour. As a beginning, two blocks of two houses each will be constructed, one block of concrete, the other of brick.

## PROPOSED NEW BUILDINGS AND WORKS.

**Doncaster.**—Plans are being prepared for a new ice works and cold storage plant for the Sheffield Pure Ice Co. The building will be constructed of reinforced concrete throughout. The plans are being got out by Mr. T. H. Johnson, Priory Place, Doncaster.

**New Mills.**—Plans have been provisionally passed for laying out about sixteen acres of the Eaves Knoll Estate in drives, each a quarter of a mile long. An electricity station and concrete houses are to be built.

**New Wharves, New York.**—The Cunard Co. have decided to spend £6,000,000 on the construction of eight steel and concrete piers at Weehawken, on the New Jersey side of the Hudson River. The piers will each be double decked, 1,100 ft. in length, and fitted with the most modern machinery for handling cargo.

The piers are intended for the exclusive use of freighters and will form an important addition to the facilities of the port of New York. They will be used by the ships of various other companies, particularly the Anchor Line and the Edye and Booth steamers.

## NEW SYSTEMS OF CONSTRUCTION.

**The Whitehall Concrete Co.**—One of the systems of construction passed by the Ministry of Health during the last month is that of the Whitehall Concrete Co., of Leeds. The system comprises patent walling slabs employed in conjunction with other pre-cast units—beams, floor slabs, heads, sills, etc.—the details of which naturally vary in accordance with the requirements of particular building works.

The walling slabs are 36 in. long by 12 in. deep by 2 in. thick, and are reinforced with expanded metal turned into the cavity forming the columns, as shown on the detail plan. The projecting ribs are cast either at the ends or at the centre of the slabs, thus enabling a continuous column to be formed whilst an alternating joint is obtained in the walling courses.

The walling slabs are manufactured from selected and screened hard clinker, the outer slab being made waterproof and the internal slab non-waterproof.

We are informed that no external applied finish is necessary, as the slabs themselves have a pleasing rough-cast appearance. A single plaster skin internally is all that is required.

The inventors state that the slabs have been employed successfully both in housing and in commercial buildings—in the latter case, in conjunction with an ordinary reinforced concrete or structural steel " framed " building.

**The Clifton-Ewart System.**—A concrete housing scheme, for which patents have been taken out by Messrs. W. Clifton and Ewart, Nottingham, claims to make it possible to erect a house in a fortnight, at a cost of £450, or with the subsidy, £300. The scheme, the plans of which have been approved by the Government Commission on Housing, consists of uprights of reinforced concrete into which an outer slab of concrete and an inner slab of plaster are inserted and locked together by pouring a group of ashes and cement between them. The insertion of the slabs is provided for by making a deep recess into the uprights on either side, the liquid pressure of the group forcing both slabs tightly into place against a rebate. The walls are string-coursed, and the floors or roofs all lock together. No wood is used except doors and window frames. There are no slates or tiles. The plastering is already done when the walls are built, and every part is made exactly to size in moulds. The first house, to be started shortly, will be designed as an artisan's dwelling; there are three bedrooms, bathroom, lavatory, living room, parlour, scullery, and linen cupboard; also a commodious hall with a portico in front. The stairs, too, are made of concrete.

The architect for the whole scheme is Mr. H. Goodall, Wheeler Gate, Nottingham.

**A New Hollow Concrete Block.**—A demonstration was given last month at the City and Guilds Engineering College of the manufacture of a new form of concrete block. The block is solid in appearance, and full-faced on all six sides, it being claimed that the thickness of the walls is proportioned in accordance with the loads to be carried. In the demonstration witnessed by us the blocks were made without machinery in stamped metal moulds, the concrete being mixed by hand. The inside faces of the blocks can, if desired, be finished in coke breeze, and the outside and end faces with plain, moulded, ornamental, ashlared, or other surfaces. Although standard sizes have been adopted for the blocks at present, we are informed that they can be made of any reasonable shape and size. Among the advantages claimed are:—(1) Strength, with minimum amount of material, and minimum weight to be handled; (2) saving in erection costs; (3) chimney construction is simplified; (4) special reinforced hollow blocks can be made for special purposes at a slight increase of cost. A company is being formed for developing these blocks.

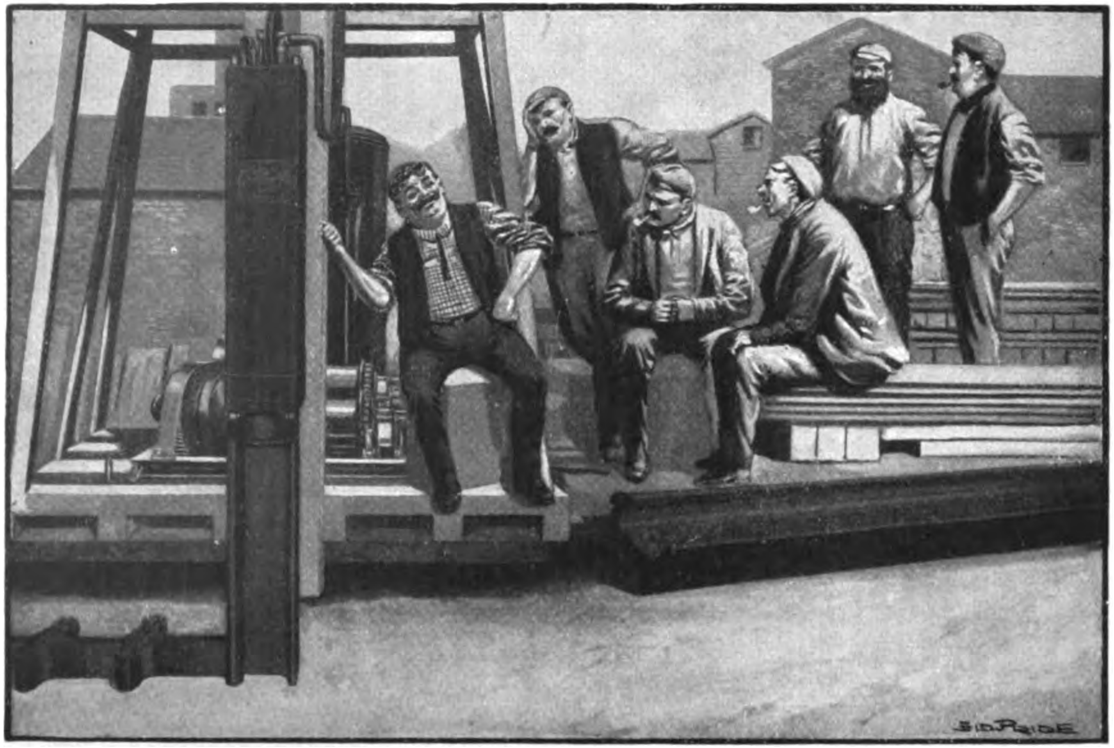
## PERSONAL.

Mr. Ewart S. Andrews, B.Sc.Eng., of 204-6, Bank Chambers, 329, High Holborn, London, W.C.2, asks us to state that he is preparing a paper to be read before the Concrete Institute next session on " Waterproof Concrete," and that he will be glad to receive particulars of any relevant experiments made by engineers and architects or of proprietary preparations being marketed by various firms.

In our issue of June, 1919, we mentioned that Major G. S. Heathcote, M.V.O., O.B.E., had formed a new company under the title of " Constructions Rapides (France and Belgique), Ltd.," for the purpose of carrying out reconstructional work in the devastated areas of France and Belgium. We are now informed that his new company has formed a subsidiary company to run the English business under the title of " C.R. Building Constructions, Ltd.," whose temporary offices are at 19, Castle Street, Falcon Square, London, E.C.1, and where Major Heathcote's firm will carry on his previous activities in reinforced concrete and constructional steelwork. A feature of the English company's business will be the exploiting of the " C.R." system of pre-cast concrete, for which they are the sole licensees. An article appeared in our issue of April, 1919, on this method of construction under the title of the " Manchester " system, which does not apply to any patent forms of reinforcement but to the method of pre-casting and assembling, to obviate all shuttering in situ, and so save expense and time. A booklet dealing with the system can be obtained on application to the above address.

## CHANGE OF ADDRESS.

**Messrs. Peter Lind & Co.,** designing engineers and contractors for all types of reinforced concrete structures, have removed to 2, Central Buildings, Westminster, S.W.1, to which address all communications should now be sent in order to avoid



THE BRITISH STEEL
PILING CO.,
DOCK HOUSE,
BILLITER STREET,
LONDON, E.C.3.

'ARRIS.—Now, boys! Here's an end to yer troubles: take over this 'ammer, what'.l make yer bonuses go up like sky rockets

WORKMEN.—An' do yer reckon we'll make more than on that old drop 'ammer?

'ARRIS.—Make more! Why, I've just come off a Shipyard job in Ireland with one o' these McKiernan-Terry 'Ammers what drove 845 piles in 17 days—nearly 44 a day! You take it from me there ain't another 'ammer will work for you like that.

WORKMEN.—Right ho! Here goes for a new bonnet for the missus.

delay. Their recent removal from Parliament Mansions to more commodious premises had become necessary in order to cope satisfactorily with the continually increasing demands upon their various departments. Telegraphic address and telephone number remain unaltered—viz.: " Inneloclin," 'phone, London, and 3746 Victoria, respectively.

## PUBLICATIONS RECEIVED.

*Ministry of Labour.—The Bulletin of the Joint Industrial Councils*, containing a review of the progress and achievements of these various bodies.

*Foundations for Machinery*. By Henry Adams, M.Inst.C.E., etc. The Technical Publishing Co., Ltd., 1, Gough Square, Fleet Street, E.C.4.

## NEW COMPANIES REGISTERED.

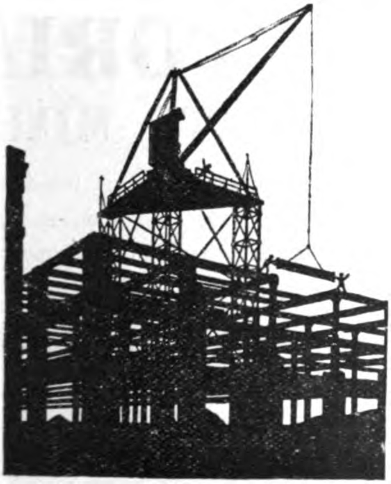
**Francois Cementation Co., Ltd** (161,759).—Registered December 17th, 1919. 701, Salisbury House, E.C.2. To construct or strengthen buildings, docks, etc., and to use cementation, silication, or other dewatering processes. Nominal capital, £750,000 in 250,000 non-cumulative 10 per cent. preference shares and 500,000 ordinary shares of £1 each. Directors: J. A. Agnew, 1, London Wall Buildings, E.C.2; F. W. Baker, 341, Salisbury House, E.C.2; and H. N. Berry, Hatfield, near Doncaster; and four others. Qualification of directors, £100; remuneration, £350 each; chairman, £600.

**Hume Pipe & Concrete Construction Co., Ltd.** (162,080).—80, Finsbury Pavement, E.C.2. Registered December 24th, 1919. To carry on the business of manufacturers of reinforced and other concrete tubes or pipes. Nominal capital, £610,000 in 600,000 ordinary shares of £1 each and 200,000 deferred shares of 1s. each. Directors: E. Newton, 3a, Marysville Terrace, N.17; H. W. Hill, 74, Grantham Road, S.W.9; and S. W. Watson, 30, Jerningham Road, S.E.14. Qualification of directors, £500; remuneration, £400 each; chairman, £650.

**Victory Construction Co., Ltd.** (162,053).—Registered December 23rd. To carry on the business of engineers, builders and contractors, &c. Nominal capital, £10,000 in 10,000 ordinary shares of £1 each. Directors: H. Gordon Selfridge, 30, Portman Square, W.; F. D. Huntingdon, 11 Hanover Square, W.; and J. P. Lloyd, 35, Courtnall Street, W. Qualification of directors, 1 share; remuneration to be voted by company.

**Wharf Lane Concrete Company, Ltd.** (162,469).—Registered January 8th, 1920. Silver Street, Ilminster, Somerset. To acquire and carry on the business of concrete manufacturers, builders and contractors. Nominal capital, £15,000 in 15,000 shares of £1 each. Directors: W. S. Growtage, 18, Church Street, Bridgwater; W. A. Hutchings, Silver Street, Ilminster; and I. J. Morgan, Townsend, Ilminster. Qualification of directors, one share; remuneration to be voted by company.

The "C. R." Patd. SYSTEM OF PRECAST
REINFORCED CONCRETE



A Unit System Retaining Full Monolithic Properties

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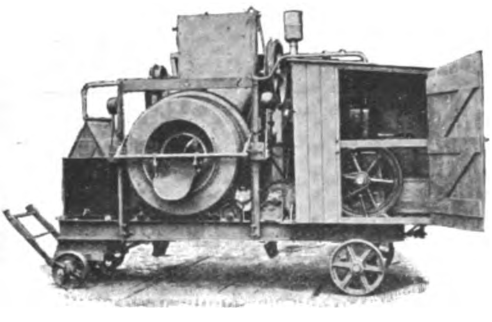

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# CONCRETE
# AND
# CONSTRUCTIONAL ENGINEERING

UNIV. OF MICH. APR 9 1920

**MARCH 1920. VOL. XV. No. 3.**

***A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.***

ISSUED MONTHLY

## CONTENTS.

**Editorials.**

**Retaining Walls for Large Buildings:**
**Messrs. Selfridge's New Building.**

**Problems in the Theory of Construction:**
**Rigid Reinforced Concrete Beams.** (*Concluded.*) **By EWART S. ANDREWS, B.Sc.Eng., etc.**

**The North Eastern Railway Concrete Sleepers.**

**The Construction of the Best Concrete Highway in Canada.**
**By A. E. WYNN, B.Sc., A.M.Am.Soc.C.E.**

**Concrete Cottage Building.**

**Design for a Water Tower.**
**By FRANK H. HEAVEN, A.R.I.B.A.**

**The Behaviour of Reinforced Concrete Columns under Fire Test (Part I.)**
**By WALTER A. HULL, U.S. Bureau of Standards, Pittsburgh, Pa.**

**Housing Exhibition at Olympia.**

**Recent Views on Concrete and Reinforced Concrete:**
**The Attrition of Concrete Surfaces Exposed to Sea Action:**
**By J. S. OWENS, M.D., Assoc.M.Inst.C.E.**

**Reinforced Concrete in Theory and Practice.**

**Concrete Shipbuilding.**

**The Foreign Press.**

**New Books. Memoranda.**

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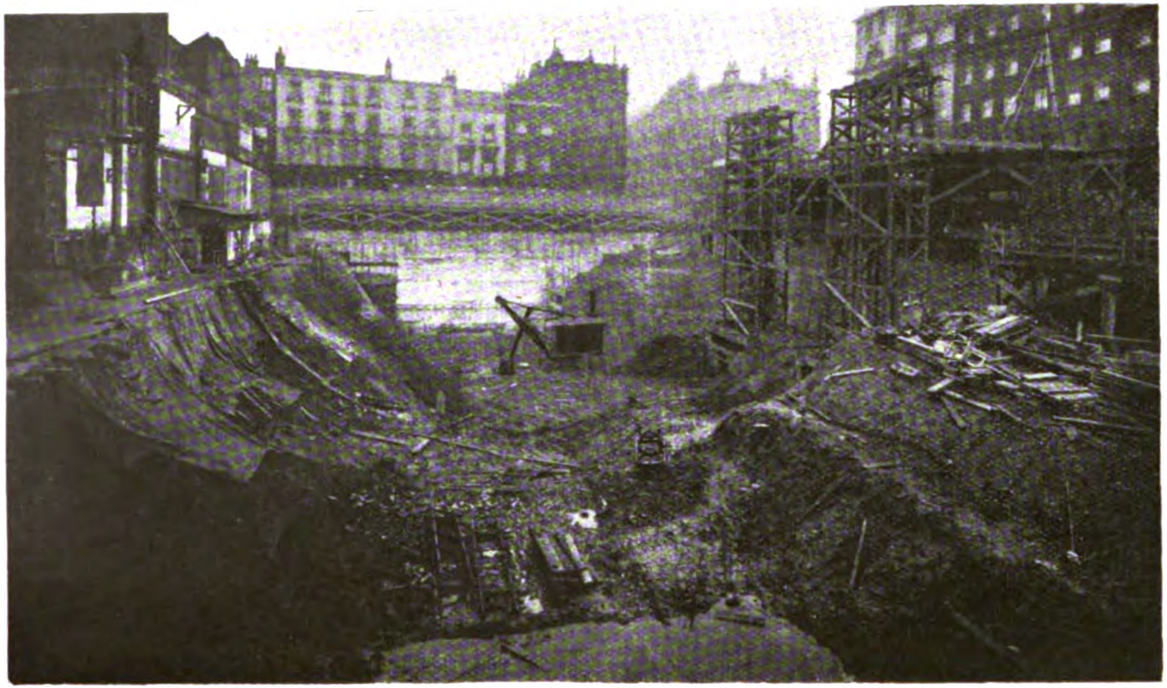


Foundations for Messrs. Selfridge's New Building.
(*For description see page* 155)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XV. No. 3. LONDON, MARCH, 1920

# EDITORIAL NOTES.

## THE FIRE RESISTANCE OF CONCRETE.

IN this issue of CONCRETE we commence the publication of an informal series of articles and abstracts dealing with the fire resistance of various types of concrete structures. During the years of the war organised experiments were carried out in Pittsburgh by the United States Bureau of Standards, in London by the British Fire Prevention Committee, and in Berlin by the German Society for Testing Materials. The American tests, an account of which begins in this number, dealt with reinforced concrete columns; the British with plain and reinforced concrete floor slabs; and the German with specially built buildings in which a number of different types of materials were incorporated. Almost simultaneously in three countries the need for more definite knowledge of the capacity of different materials to withstand the temperatures of severe conflagrations crystallised into a systematic programme of research. In each case the programme has already been carried out to a first interval, during which the reports of work accomplished may be digested, comparisons made, and deductions drawn.

### CHOICE OF MATERIALS.

It is clear that the most effective choice and use of materials can only become possible if the behaviour of each under various circumstances can be confidently foreseen. In the case of the widely different materials employed in making concrete such knowledge is particularly important. It is impossible to make generalisations about *concrete* as such, for the term concrete does not connote any definite material, but is merely a sack-name covering a wide variety of types. Each class of aggregate has, for any particular purpose, its own special advantages and disadvantages, and when these have been experimentally determined, it is essential in the interests of economy—both of money and time—that every aggregate tested should be described so accurately that all similar aggregates throughout the world can easily be recognised. A comprehensive series of tests carried out with representative types and combinations of materials will then serve, once and for all, as a standard of reference, and the properties of different rocks, bricks, slags and other by-products and of their combinations with different types of steel reinforcement may then be at once deduced.

### COMPARISON BETWEEN AGGREGATES.

In order, however, that comparisons between aggregates may safely be made, the nature of the untested aggregate must often be determined more accurately than has hitherto been done. It is not enough to decide that one granite will act like another: the sizes of the constituent crystals may differ widely, and as regards fire resistance this is an important consideration. Similarly, with limestones, a fine-grained stone will withstand heat more successfully than one containing large crystals. Again, it is not enough to assert that one gravel will behave like another: the mineral composition of the different pebbles and smaller fragments may also differ widely. Just as it is necessary to know what kind of concrete is being considered before one can describe its properties, so it is essential to know what kind of gravel is being used in order to judge the likelihood of its success or otherwise.

The programme of tests carried out by the British Fire Prevention Committee has been correlated throughout with careful geological, mechanical, and physical researches, and the results therefore are not only of national, but of world-wide importance. As their reports and memoirs are published we shall have ample opportunity to discuss their significance. In the meantime we may briefly consider the American findings.

### SOME AMERICAN FINDINGS.

As a perusal of the abstract of Mr. Hull's paper will show, it has been clearly demonstrated that three different kinds of gravel-aggregates, all containing quartz in abundance, failed badly during the fire-tests, and that limestone, long regarded with suspicion, withstood the stress of similar tests with a remarkable degree of success. In the second part of Mr. Hull's paper the results obtained with " trap-rock " and blast furnace slag are also shown to be highly satisfactory compared with those of quartz-bearing gravels. It is now certain, not only from the Pittsburgh tests, but also from the British and German tests, and from the dangerous and more expensive experiences of actual conflagrations, that aggregates containing quartz in any abundance (quartz-gravels, granites, and sandstones) behave extremely badly under fire. Moreover, flint, which is almost the sole ingredient of Thames ballast, makes a still less desirable aggregate.

This important conclusion might, indeed, have been expected from a consideration of the thermal properties of quartz and granite. Experiments carried out before the war in the geophysical laboratories of the Carnegie Institution of Washington showed that quartz expands by more than 5 per cent. of its volume on being heated to 600°C. (1090°F.). Granite expands even more, and suffers a marked loosening of texture and loss of strength. Dolerite (the " trap-rock " of the American tests) at once reveals its superiority, for it expands by less than 3 per cent. at 600°C., while at higher temperatures the comparison is still more favourable.

### PROTECTIVE COVERINGS.

Unfortunately, most gravels contain flint, quartz, or quartz-bearing rocks as their chief ingredients, and at the same time their abundance and wide distribution have led to their being widely adopted as aggregates. It is therefore a matter of serious economic importance to ascertain whether it would not be possible safely to use flint or quartz-bearing gravels for concrete by protecting the latter with fire-resistant coverings. It may perhaps be questioned whether such procedure is practicable in view of the expense and nicety of technique which is involved. However, that is a matter for future demonstration after the degree of efficiency obtainable by such methods has been established. The second part of Mr. Hull's paper deals, among other topics, with the protection afforded by gypsum, plaster, and other coverings, and the subject is one which has also received very careful attention in this country. At the moment, however, in the absence of detailed findings, it is scarcely possible to decide whether or not a simple cheap, and efficacious protective covering has yet been devised. In the meantime it is safe to say that crushed limestone, dolerite or basalt, slag, and brick are far superior in their fire-resisting properties to flint-gravels and quartz-gravels and other aggregates which contain abundant free silica.

## THE IMPORTANCE OF SKILLED SUPERVISION IN CONCRETE WORK.

THE need for conscientious workmanship, strict adherence to specification and skilled supervision in important concrete work has been emphasised recently by the deplorable accident in Birmingham when a newly constructed reinforced concrete roof collapsed, resulting in the loss of five lives.

As far as the accident itself is concerned the facts are as follows: A flat reinforced concrete roof was constructed, apparently in the usual way, and a period of 28 days was allowed for the material to set and harden. At the end of this time the centering was removed and the roof collapsed with the result stated. Under normal conditions the period of twenty-eight days would have been considered ample for the setting of the concrete and the stability of the structure. But what are normal conditions?

In spite of the many claims made, and justly made, as to the simplicity of operations in concrete, the material is not "fool-proof." In all concrete work, but especially in important undertakings which involve the safety of life and limb there are certain essentials which cannot be neglected. These are: the soundness of the design, the quality of the material employed, strict adherence to specification, good workmanship and efficient supervision.

As might have been expected after an accident of this nature, a close investigation was made and independent expert advice was called in. The result showed that the design was sound, the material was good, and the specification had been drawn up with reasonable and ordinary care and skill.

The verdict of the jury was "accidental death," but a rider was added that, in their opinion, "there was not sufficient technical supervision over the execution of the work."

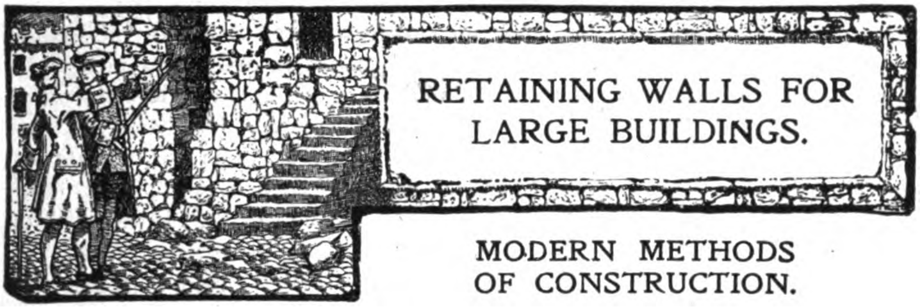
After the expert evidence submitted, the coroner is reported to have expressed himself as being quite satisfied that the design was sound and that the material was good but that the foreman (who was among the killed) had "had too much put upon him."

## GENERAL NOTES.

IN response to requests which have reached us from time to time, we have arranged to publish a series of articles dealing, in the simplest possible manner, with the design and the underlying principles of reinforced concrete. These articles are being written for us by Dr. Oscar Faber, and should prove particularly useful to students and others who are commencing to take up the study of reinforced concrete and its applications to various forms of structures. The first article appears in this number on page 207.

We have been fortunate in securing an article for this issue from the pen of Mr. A. E. Wynn, formerly Engineer of Bridges on the Toronto-Hamilton Highway Commission of Canada. The article deals with the Toronto-Hamilton Concrete Highway and contains many points of interest relating to the construction of concrete roads. The author devotes special attention to the question of materials and the methods of handling them, and emphasises the necessity of careful selection of material and the correct proportioning of cement and aggregate. The Toronto highway, it is pointed out, covers a distance of thirty-five miles and represents the best and most modern practice in concrete road building in Canada.

We again call the attention of readers to the book to be published shortly from this office, dealing with Concrete Roads. As previously stated, it will include a survey of concrete roads in this country and the experience gained from them. There will also be a chapter dealing with modern mechanical equipment.



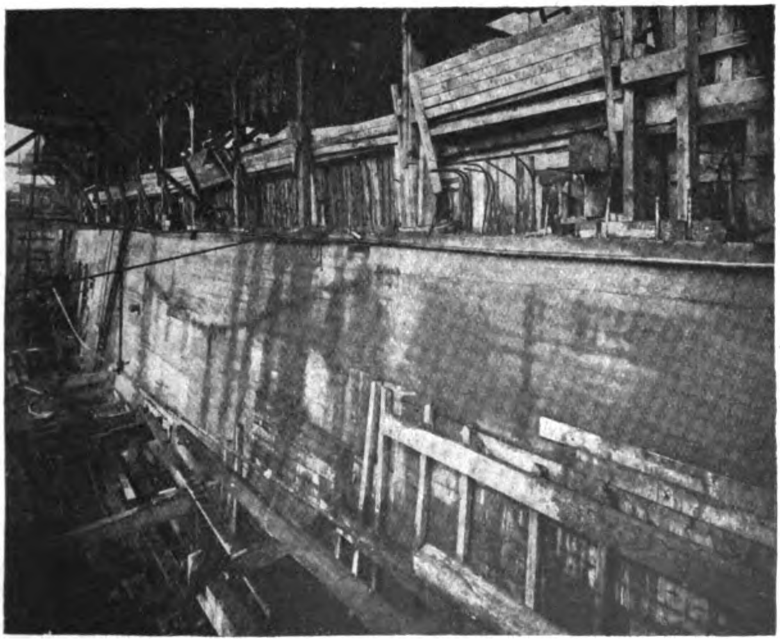
# RETAINING WALLS FOR LARGE BUILDINGS.

## MODERN METHODS OF CONSTRUCTION.

*Concrete has for many years been one of the recognised materials with which to construct retaining walls; the use of it, therefore, for that purpose in connection with Messrs. Selfridge's new building does not constitute a novelty. The method in which this particular work was carried out, however, was somewhat unusual, and may therefore well be of interest. We are indebted to the "Builder" for the loan of the blocks illustrating this article.—ED.*

---

THE customary procedure for clearing a site for the erection of a large building is to excavate the whole area, supporting the surrounding roads and buildings meanwhile with raking shores which greatly interfere with the rapid progress of the work and constitute a certain element of risk. The retaining walls are then built from the bottom upwards as the shores are removed.



RETAINING WALL OF FOUNDATIONS FOR MESSRS. SELFRIDGE'S NEW BUILDING.

It was consequently decided on this occasion to abandon this method and to dig trenches against the two road frontages of Orchard Street and Somerset Street to accommodate the retaining walls; a sufficient amount of earth being left against the backs of the Oxford Street frontage, however, to render them self-supporting.

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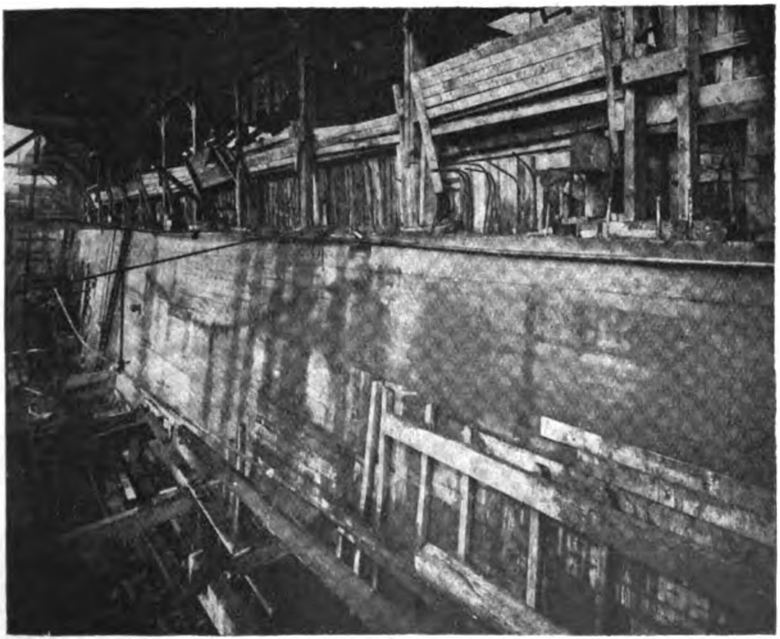

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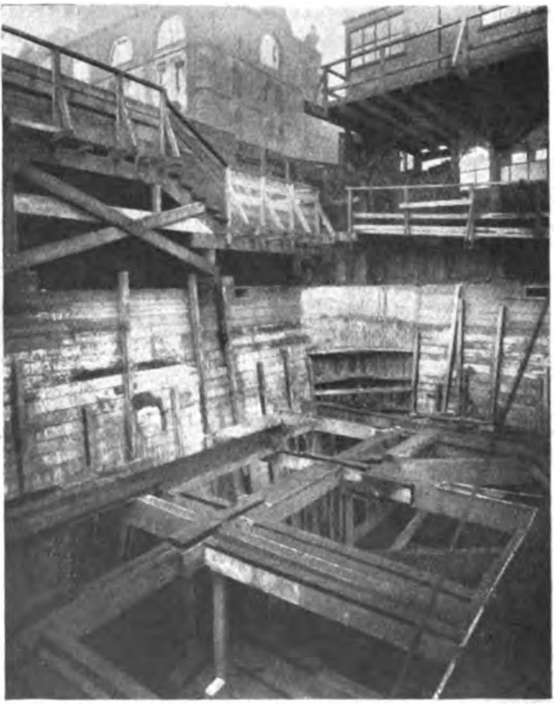
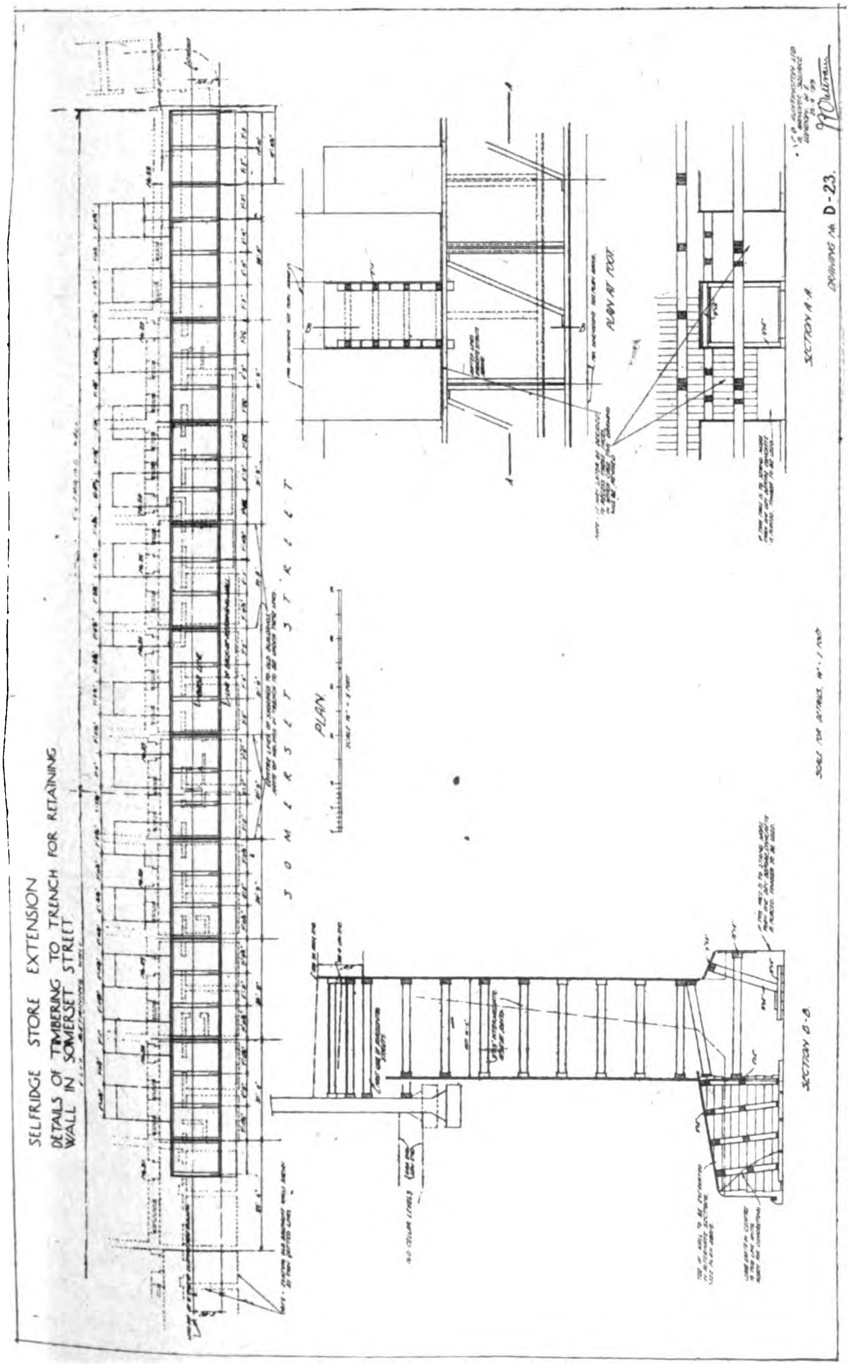
It was consequently decided on this occasion to abandon this method and to dig trenches against the two road frontages of Orchard Street and Somerset Street to accommodate the retaining walls; a sufficient amount of earth being left against the backs of the Oxford Street frontage, however, to render them self-supporting.

The mode of excavating these two trenches differed owing to varying governing conditions. The trench along Somerset Street was begun before the existing houses were demolished and this fact limited the width of the trench to 10 ft., the inner face being cut as near to the foundations of the old buildings as safety would permit. The width of the toe of the wall measures, however, 30 ft., and this necessitated considerable undercutting, which was done in alternate bays of 7 ft. The exact position of these bays was governed by the placing of the struts supporting the timbering to the trench, and these were aligned with the raking shores against the fronts of the old buildings, which, as a matter of course, were placed opposite to lateral walls. So that it may be said that the whole method employed both for the excavation and for the timbering of the Somerset Street trench was governed by the plan of the existing buildings along that particular road frontage which were, at the time of beginning the work, not yet demolished, although the excavation of the trench and the demolition of the houses were conducted as simultaneous operations.

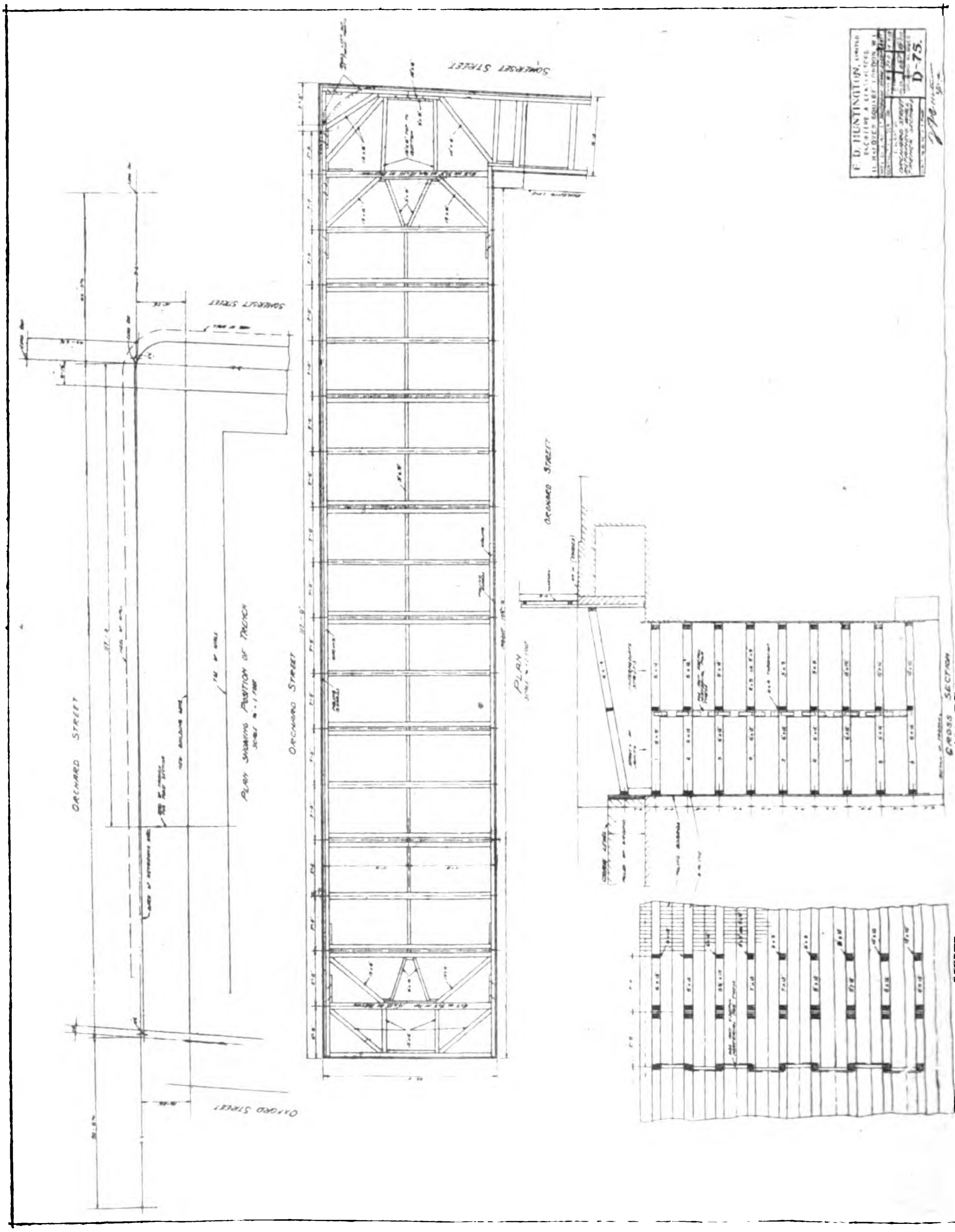


Retaining Wall against Orchard Street.

The work in connection with the trench against Orchard Street was a simpler matter. Here it was possible to excavate for the full width of the wall and toe, the only undercutting which was necessary being a small amount required for the heel of the wall. The walls are, of course, reinforced throughout, and this fact necessitated a special method of timbering for the trench. Had the timbering been carried out in the usual way, with poling-boards, waling-pieces and struts


SELFRIDGE STORE EXTENSION
DETAILS OF TIMBERING TO TRENCH FOR RETAINING WALL IN SOMERSET STREET
SOMERSET STREET
PLAN
PLAN AT FOOT
SECTION A-A
SECTION B-B
DRAWING No. D-23

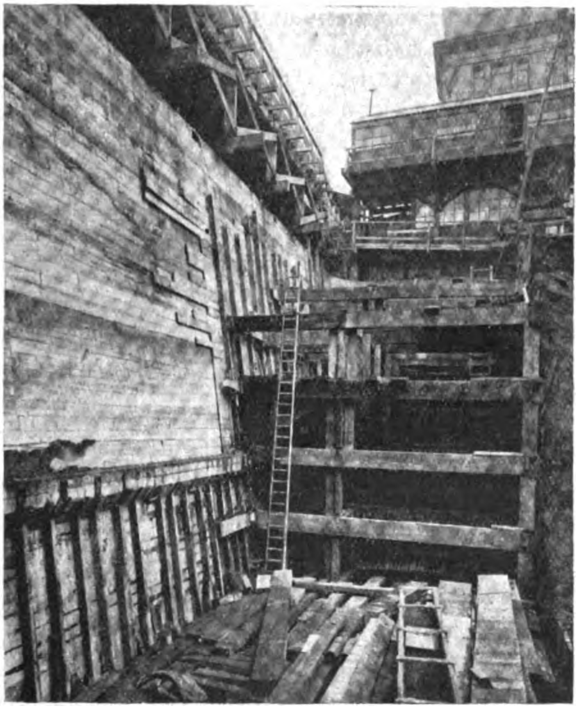
Foundations for Messrs. Selfridge's New Building.



Foundations for Messrs. Selfridge's New Building.

it would not have been possible to insert the rods in their proper place close to the surface of the wall owing to the presence of the waling-pieces. It was, therefore, necessary to insert packing-pieces, and thus form a comb between the poling-boards and the walings, through which the rods could be thrust.

The concrete, of which the mixture was 4 to 1, was mixed by means of mechanical mixers, suitably disposed about the site. To ensure the waterproofing quality of the walls. "Anti-Hydro," a patent liquid which is manufactured by the Adamite Co., Ltd., of Regent House, was incorporated in the mixture; one gallon of Anti-Hydro being used with every cubic yard of cement. The top of the retaining wall reaches to within about 4 ft. of the upper surface of the pavement, thus leaving a space for conduits under the pavement. The space between the retaining wall and the main structure is used to increase the area of the basement and sub-basements; the former being lit by means of pavement lights. Thus the retaining wall receives additional support from the steel work of the floors.



Retaining Wall, Corner of Somerset Street and Orchard Street.
MESSRS. SELFRIDGE'S NEW BUILDING.

A governing factor in the conduct of these works has been a determination to utilise to the full every available mechanical device for simplifying and economising in human labour. Thus for the main excavation a ¾ yd. Erie revolving shovel is employed (*See Frontispiece*). The use of a mechanical navvy on a building job of this description constitutes a somewhat novel feature, its use having, for the most part, hitherto been confined to reservoirs, railways and the like. The machine is capable of removing from 50 to 60 c. yds. per hour. The earth removed by the navvy is dropped into tip-wagons, these are run into lifts and taken up to platforms about 9 ft. above the street level, here they are emptied into bins which discharge straight into the carts standing on the road beneath. Two sets of double lifts are employed for this work, each driven by a 40-h.p. motor.

The retaining walls, which vary in depth from 45 ft. at the shallowest point to 75 ft. at the deepest, having been completed, the excavation of the ground to the level required for the lowest sub-sub-basement proceeds apace, and the further excavation required for the foundations of the individual stanchions is then undertaken. The size and depth of these varies of course with the loads which they are called upon to carry. The areas of these foundations, which rest upon orthodox London clay, vary from 3 ft. 9 in. by 3 ft. 9 in. to 15 ft. by 15 ft., and the depth from 3 ft. to 6 ft. The foundations are all of reinforced concrete, no particular system being employed. On most of the stanchion foundations there is a cast-iron base, around which the concrete is flaunched up, and from which the steel work rises, bedded, of course, where it would otherwise be in direct contact with the earth. Where these foundations come immediately over the toe of the wall, it has been necessary to use steel grillages instead of the cast-iron bases, owing to the fact that less depth is available.

The contractors, Messrs. F. D. Huntingdon, Ltd., are working to a time-table, and the new building is being carried out in successive stages, so that as Messrs. Selfridge are compelled to vacate old premises, they will be able to move straight into a portion of the new building, which will by that time be completed to first floor level; this floor acting as a temporary roof to the ground floor which they will occupy. The whole work is to be done in four successive stages in this way, the erection of the tower being left until the remainder of the building is completely finished. The architects for the work are Messrs. Graham, Anderson, Probst and White, with whom is associated Sir John Burnet, R.S.A., LL.D.

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# PROBLEMS IN THE THEORY OF CONSTRUCTION.

## RIGID REINFORCED CONCRETE FRAMES.

By EWART S. ANDREWS, B.Sc.Eng.; M.C.I.

*Continued from the February Number, p. 80.—ED.*

DERIVATION OF FORMULA FROM GRAPHICAL CONSIDERATIONS.—Since from $A$ to $B$, $\frac{\delta B}{\delta H} = x$, it will be seen that $X_1$ is $\frac{1}{EI_c}$ times the moment about $A$ of the area of the Bending Moment Diagram; also since from $B$ to $C$, $\frac{\delta B}{\delta H} = h$, $X_2$ and $X_3$ are $\frac{1}{EI_B}$ times the moment about $AA^1$ of the area of the bending moment diagram from $B$ to $C$.

We then have $X_1 = \frac{1}{EI_c} \times (-Hh)\frac{h}{2} \cdot \frac{2h}{3} = \frac{-Hh^3}{3EI_c}$

$$X_2 + X_3 = \frac{1}{EI_B} \times h \times \left\{ \frac{W}{2} \cdot \frac{a}{2} + Wa\left(\frac{l}{2} - a\right) - Hh \right\}$$

By putting $X_1 + X_2 + X_3 = 0$ we obtain the same results as before.

To save possible misunderstanding we would like to point out at this stage that we have chosen the one of the cases considered by Dr. Abe, the formulæ for which are the simplest to demonstrate; in the bulletin the results are given for a large number of other cases, mostly more complicated, but the student should not have much difficulty in following them once he has followed the reasoning given above.

REACTION LOCUS FOR SINGLE ISOLATED LOAD.—It is clear from considerations of symmetry that each of the loads shown in *Fig.* 1 must contribute equally to the horizontal thrust; if therefore we have a single load $W$ at distance $a$ from one end, it is clear that the horizontal thrust $H$ is given by

$$H = \frac{3\,Wa\,(l - a)}{2hl\,(2s + 3)} \qquad (5)$$

Dr. Abe shows that a reaction locus for this case can be obtained as follows (see *Fig.* 2):—

Let the resultant reactions $R_A$ and $R_{A^1}$ meet the line of action of $W$ at the locus point $L$.

By taking moments about $L$ we have

$$V_A a = H\alpha h$$

$$\text{—i.e., } \alpha h = \frac{V_A a}{H} \qquad (6)$$

Also

$$V_A = \frac{W(l-a)}{l} \text{ (by moments about } A^1) \tag{7}$$

$$\therefore \alpha h = \frac{W(l-a)\,a}{Hl} \tag{8}$$

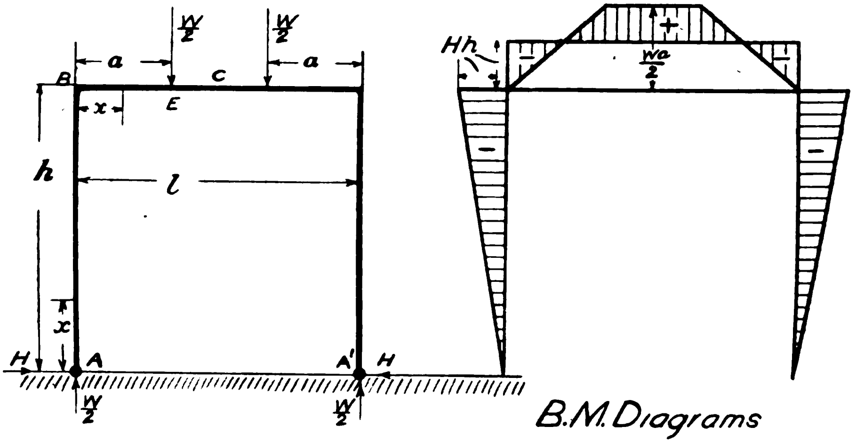

FIG. 1.

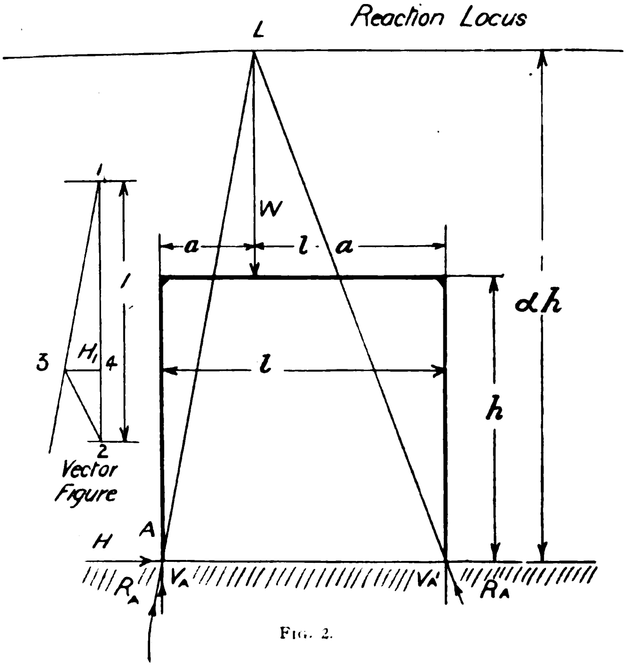

FIG. 2.

$$= Wa(l-a) \div \frac{3\;Wa\;(l-a)\;.\;l}{2hl\;(2s+3)}$$

$$= \frac{2h\;(2s+3)}{3}. \tag{9}$$

This is independent of $a$—*i.e.*, the position of the load, so that for any position of the load the locus point $L$ will come upon a straight line at height $\alpha h$ given by equation (9).

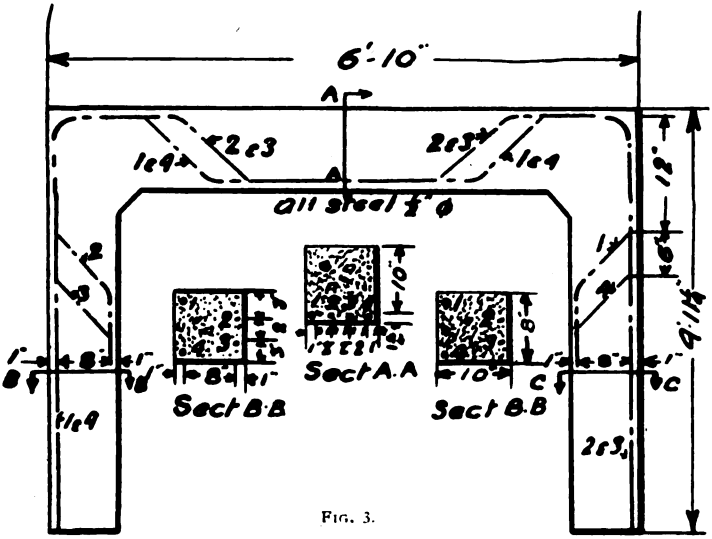

FIG. 3.

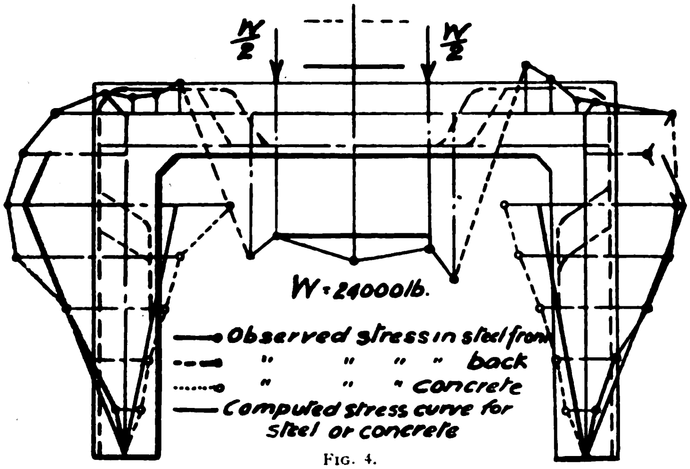

FIG. 4.

In the case, for instance, in which $s = 1$, $\alpha h = \frac{10h}{3}$

This gives us the following graphical construction for determining the horizontal thrust for a unit load placed at any point.

Draw the reaction locus and set down a length 1, 2 to represent a unit load; draw a vertical through the point at which the load is applied to intersect the locus in $L$ and join $LA$, $LA^1$; then draw 1, 3 parallel to $LA$ and 2, 3 parallel to $LA^1$ and a horizontal 3, 4 through the point of intersection gives the unital horizontal thrust $H_1$, then

$$H = H_1 \times W \tag{10}$$

Application to a number of isolated loads.—If we have a number of isolated loads upon the top beam, we can find the total horizontal thrust by drawing the vector diagram for each position of the load, multiplying each unital horizontal thrust by the corresponding load and adding the results together; expressing this in symbols we have:—

$$H = \Sigma H_1 \times W \tag{11}$$

Particulars of frame tested.—*Fig.* 3 shows one of the frames which were tested and which we will consider in detail. The effective span $l$ is 6 ft. and the load is applied at the third points so that $a$ is 2 ft.; $h = 4{\cdot}5$. In the beam section we have at the centre, using the Concrete Institute notation:

$$d = 10,\ b = 8,\ A = {\cdot}785,\ p = \frac{{\cdot}785}{80} = {\cdot}0098.$$

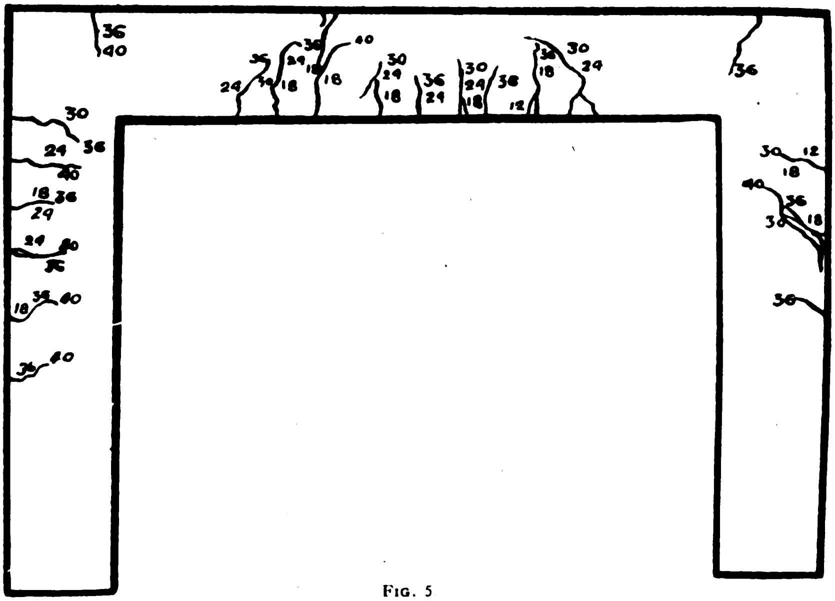

Fig. 5

From curves of neutral axis depths we see that

$$n = {\cdot}41d = 4{\cdot}1\ ;\ \therefore\ d - n = 5{\cdot}9$$

$$\therefore\ I_B = \frac{bn^3}{3} + 15\,A\,(d - n)^2$$

$$= 184 + 410 = 594 \text{ in. units.}$$

In the column section we have at the point of maximum bending moment

$$d = 9,\ b = 8,\ A = {\cdot}785.\ p = \frac{{\cdot}785}{72} = {\cdot}0109.$$

$$\therefore\ n = {\cdot}43d = 3{\cdot}87\ ;\ d - n = 5{\cdot}13.$$

$$I_c = 154 + 310 = 464 \text{ in. units.}$$

$$\therefore\ s = \frac{I_B h}{I_c\, l} = \frac{594 \times 4{\cdot}5}{464 \times 6} = {\cdot}96$$

$\therefore$ by equation (5)

$$H = \frac{3\ .\ W\ .\ 2\ .\ 4}{2\ .\ 4{\cdot}5\ .\ 6(1{\cdot}92 + 3)} = {\cdot}09\,W$$

This is in fair agreement with Dr. Abe's value of ·082 $W$; no information appears to be given in the bulletin as to how the moments of inertia were computed.

If we take for the pillar section the moment of inertia just below the top where there are only three bars we get $H = \cdot 084\ W$; this is probably what Dr. Abe has done and is on the whole quite justifiable.

INTERPRETATION OF RESULTS.—*Fig.* 4 shows a comparison of the calculated and observed stresses, obtained by extensameter measurements for a load of 18,000 lbs. The ultimate load carried by the frame was 40,500 lbs., and this load was held for a few minutes and then dropped very slowly.

*Fig.* 5 shows the cracks developed during the test, the figures alongside them indicating the load at which they appeared. The first fine cracks appeared at a load of 12,000 lb. directly under a load point and the outline edge of the column on a level with the underside of the beam.

The cracks ultimately developed were well distributed in the tension zone and no crack due to diagonal tension appeared; ultimate failure occurred by the tension in the reinforcement.

POINT OF CONTRAFLEXURE OF COLUMNS FIXED AT THE ENDS.—The tests show that the point of inflexion in the column when fixed at the ends is at almost exactly one-third of the height as indicated by theory; the position of the point changed very little during the progress of the loading.

In a frame of the same dimensions as in *Fig.* 3 but with its ends built into the base, the first crack appeared at a load of 21,000 lbs., and the ultimate load was 60,000 lbs.

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# THE NORTH EASTERN RAILWAY.

## CONCRETE SLEEPERS.

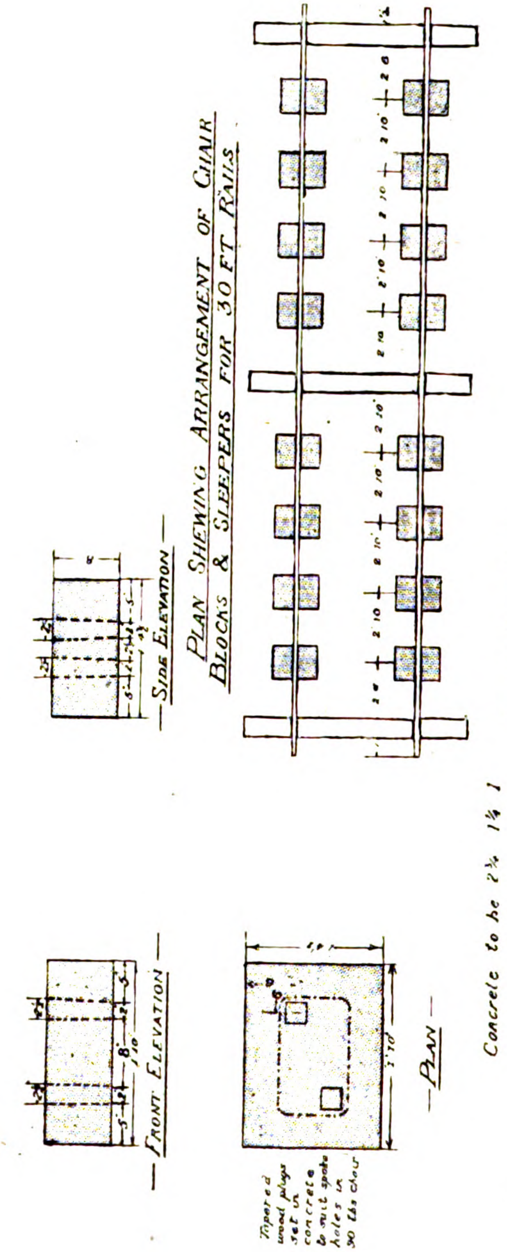
THIS Company, as is well known, have deservedly earned for themselves a decided reputation for the excellence and varied character of their concrete productions. Some few years since, we referred fully in these pages to the many interesting and useful articles they were making at Severus Junction Concrete Depot for use on their line. Even at that period they were laying quite a large number of concrete block sleepers, using a timber sleeper between every set of five concrete blocks to tie the line.

These blocks have so completely justified their adoption that, in consequence, the Company are ever increasing the use of them.

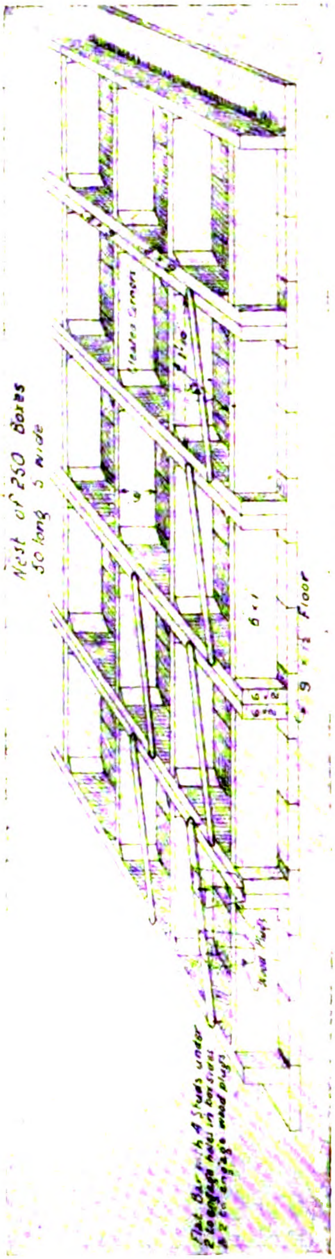
The block sleepers of to-day differ only in depth from those at first made, and something like 15,000 of this type for use on a section of the North Eastern system at Hull are being installed. We can state with authority that these concrete chair blocks are now being used in considerable quantities in the place of timber sleepers for coal wagon standage sidings and sidings at road-side stations. In fact, they are suitable for any sidings that are laid on the straight or on an easy curvature which are not being continuously passed over by heavy main line locomotives.

*Fig.* 1 shows the blocks to be 8 in. deep, but it has been found possible to reduce this to 6 in. without impairing their efficiency.

*Fig.* 2 shows the arrangements that are in use at Hull for moulding the blocks, which are self-explanatory.


Plan Shewing Arrangement of Chair Blocks & Sleepers for 30 ft Rails
Side Elevation
Front Elevation
Plan
Concrete to be 2½ 1¼ 1
Tapered wood plugs set in concrete to suit spike holes in 90 lbs chair
2'10"

Concrete Chair Blocks.



Forms for making Concrete Sleeper Blocks.

The main point in the manufacture is to soak the wooden spike plugs for not less than 24 hours, so that they cannot absorb any further moisture from the wet concrete, and by swelling, fracture the blocks.

View of finished road at Oakville.
Toronto - Hamilton Highway.

# THE CONSTRUCTION OF THE BEST CONCRETE HIGHWAY IN CANADA.

By A. E. WYNN, B.Sc., A.M.Am.Soc.C.E.
*(Formerly Engineer of Bridges, Toronto-Hamilton Highway Commission, Canada.)*

*The following article by the former Engineer of Bridges of the Toronto-Hamilton Highway Commission in Canada, will no doubt be of special interest to surveyors contemplating the laying of concrete roads in this country.—ED.*

---

Concrete highways have not yet attained the popularity in England that they have in the United States and Canada. This is probably due to the fact that English engineers on the whole have not first-hand knowledge of their construction and efficiency.

They have been built so extensively in the United States that their construction has attained a high state of efficiency, and English engineers cannot do better than follow the specifications and methods adopted in that country.

In Canada the best concrete road is that connecting Toronto with Hamilton, a distance of thirty-five miles.

The Toronto-Hamilton highway represents the best and most modern practice in road building and is as perfect a road as can be built to-day.

It is a link of the Provincial Government's scheme for a system of main highways connecting the towns and it carries more traffic than any other road in Canada.

Its construction was undertaken in the fall of 1914 as a war measure to provide employment for the large number of men thrown out of work by the war.

Before deciding upon the type of road to build, numerous roads in the United States were inspected and compared, with the result that the Commission appointed to undertake the work decided that a concrete pavement was best suited for the heavy traffic expected.

The specifications adopted very closely followed those of Wayne Co., Michigan, which is the pioneer district for concrete roads. All work was done by day labour under the supervision of the Commission's engineers.

It is only intended here to describe the construction of the actual pavement, although a great deal of work had to be done in grading, widening, ditching, etc.

The pavement itself had a standard width of 18 ft. with shoulders 3 ft. wide on each side, of the natural earth, gravel or crushed stone.

The width was increased to meet local conditions, as through towns and villages. It was 24 ft. wide for a few miles outside Toronto, and reached a maximum of 50 ft. wide through the town of Oakville.

### MATERIALS AND METHOD OF HANDLING THEM.

Firstly, let us consider the materials used and the method of handling them.

Careful selection of material and correct proportioning of cement and aggregate are of vital importance to the success of a concrete road and usually too little attention is given to it.

Only tested cement of known quality was used. Before considering any stone for use an inspector visited the quarry, and all details as to the methods of handling, screening, output per day, etc., were recorded. A sample of 100 lb. was carefully selected from different points in the quarry and shipped to the testing laboratory.

The road before concreting.
THE TORONTO-HAMILTON HIGHWAY, CANADA.

Here the following tests were made :—

(1) Resistance to wear.—(2) Resistance to impact.—(3) Specific gravity.—(4) Absorption.—(5) Weight.—(6) Granulometric analysis.—(7) Voids.—(8) Cleanliness.

Most of the stone used was limestone or dolomite, varying in size from 1½ in. down, and had to pass the above tests satisfactorily before being accepted.

All sands used were tested for cleanliness, grading and tensile strength, and from the result of these tests certain sands were decided upon to be used. The selected sands were then given the following final comparative tests :—

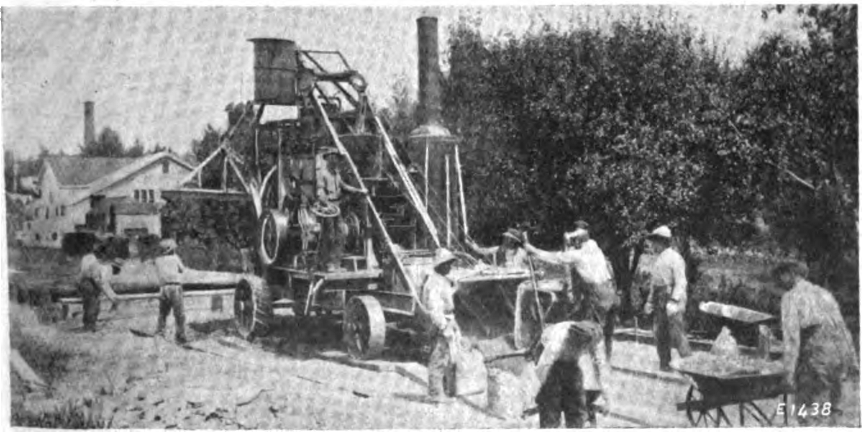
(1) Mineralogical composition.—(2) Specific gravity.—(3) Weight.—(4) Voids. —(5) Abrasion on mortar.—(6) Toughness on mortar.—(7) Absorption on mortar.

Specifications for stone and sand were based on the above tests, and samples were kept by the Commission until the completion of the work.

Every car of sand or stone was inspected before shipping, and samples were sent in periodically to the laboratory to be tested, in order to be sure that they were up to specifications. On these tests, too, was based the exact mixture to be used with a certain aggregate.

The mixture adopted was nominally 1 cement, 1½ sand, 3 stone; but this was checked up by the tests and was varied slightly to suit different aggregates. When there was any change in material the Testing Engineer gave to the Field Engineers the correct mixture to be used and the amount of water required for mixing.

The efficient handling of material is a big problem and should be studied thoroughly before commencing work.



Construction view showing the concrete mixer.
THE TORONTO-HAMILTON HIGHWAY, CANADA.

At convenient points along the road material yards were built alongside the railway, about eight miles apart. New spurs were run into each yard. The cars of material were unloaded by a clamshell bucket into large wooden storage bins with hopper bottoms.

The material was then transported to any desired point along the road by means of a narrow gauge temporary tramway; the dump cars being loaded automatically from the storage bins. The track was laid on steel sleepers and bolted together in 20 ft. sections, so that each section could be easily and economically handled by two men.

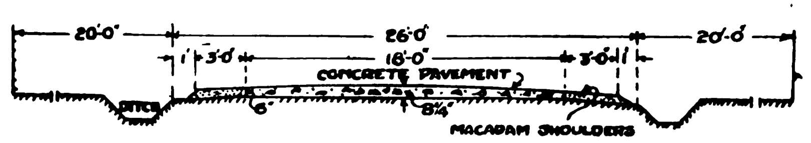
The material was deposited along the road, behind the mixer, in such quantities that, as concreting progressed and the mixer moved backwards, there was always just sufficient material on hand, with no waste nor shortage.

Each train load carried cement, sand and stone in the desired proportion, so that there was no delay in concreting due to insufficiency of one of the materials.

The subgrade consisted of the natural soil, mostly sand. It was rolled flat with a 10-ton roller and thoroughly wet down to prevent absorption of moisture from the concrete. Side forms for the concrete pavement were 6 in. iron channels, which were accurately lined up and staked in place by instrument, for some distance ahead of concreting. Materials were mixed by half cu. yd. mechanical mixers, steam driven.

Water was pumped from the nearest available supply. The amount of water used in mixing was accurately gauged by a meter fixed to the machine and was varied to suit different aggregate, but was kept constant for any particular aggregate. This correct proportioning of water is very essential in road work and is a point often overlooked. It ensures an uniform mixture and is an important point in preventing cracks.

The materials were mixed in the drum of the mixer for a specified time and the concrete was then dumped out into a bucket which travelled along a 20 ft. boom, to be deposited where required.



TYPICAL CROSS SECTION OF CONCRETE ROAD

### CONSTRUCTION OF ROAD.

The cross section of the road was a parabola, 6 in. thick at the sides and 8¼ in. at the crown, laid in one course. As the concrete was deposited it was levelled off by a template, handled by two men, and resting on the side channel forms.

Following up were the cement finishers, who worked from a wooden bridge spanning the pavement. They floated up the surface with wooden trowels, just sufficiently to bring the moisture to the surface.

No smooth surface was attempted, as a slightly rough surface gives a better foothold, and too much trowelling will bring the fine particles to the top, which would be liable to cause dust.

All pavement was laid in 35 ft. sections. Between each section was an expansion joint about ¼ in. wide, consisting of prepared asphalted felt.

This felt was laid against the end form, which was set truly in line and vertical, and the concrete was carried up to it, completing one section. Then concrete was laid the other side of the form and after setting a short time the form was taken out and the space filled with concrete. To ensure the concrete being exactly the same height on either side of the joint a special trowel was used with a groove to fit over the felt filler which projected above the pavement about ½ in.

From 300 to 600 lin. ft. of pavement were laid in one day by one mixer, all work finishing to a joint under any circumstances.

After concreting followed the "curing."

The day after the concrete was laid it was covered with 2 in. of dirt and was sprinkled with water daily for ten days. This "curing" is important to prevent too rapid drying out, and to ensure that the concrete will attain its maximum strength.

After about four weeks the dirt was removed, the joint fillers trimmed to within a quarter of an inch of the pavement surface and the road opened to traffic.

View of road after concreting.
The Toronto-Hamilton Highway, Canada.

At intervals during concreting 1 cu. ft. blocks were made and left along the road to cure in the same manner as the pavement. They were marked according to their location and were afterwards tested in the laboratory.

The pavement was not carried over culverts until after the fill had thoroughly subsided and was always reinforced with wire fabric or ordinary fencing, to prevent cracks.

The pavement as a whole was not reinforced except over bad places in the subgrade.

Building the 3 ft. shoulders was the last operation, the material used being mostly that used for curing.

No paving was carried on during the winter owing to the freezing of the subgrade and the difficulty of protecting large areas of pavement from frost.

On the other hand, all culverts and bridges were built during the winter under the severe climatic conditions that exist in Canada. They were all constructed of reinforced concrete, the longest spans being 125 ft.

Concrete was laid in very low temperatures with no ill effect. Many engineers claim that concrete cannot be laid in freezing weather, but when the material is heated and the concrete kept warm until after it has received its initial set, no harm results. The danger lies in using frozen material and in allowing the concrete to freeze before gaining its initial set.

### CONCLUSION.

Maintenance so far has been a small item and is easily covered by fines imposed upon motorists for speeding. The cracks are cleaned out and filled with tar, heated to about 225° F. Coarse dry sand is then sprinkled over, an excess of sand and tar being used, and the traffic is allowed to iron it out.

As this highway is the most important in Canada and was also the first to be constructed of concrete, considerable care was taken in its construction.

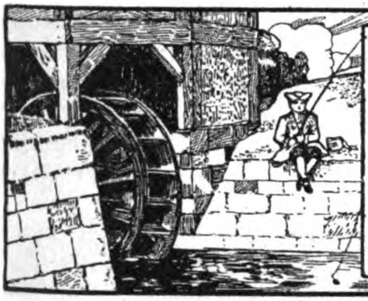
It may be taken as the most modern method of building a concrete highway.

Perhaps the most important point to note is the rigid inspection and testing of material and the scientific proportioning of the concrete constituents.

Traffic along the road has far exceeded all estimates and its general popularity should give a big impetus to concrete road construction in Canada.

View of finished road.
THE TORONTO-HAMILTON HIGHWAY, CANADA.

*[In our next issue an article will appear by Mr. Wynn on "The Causes of Cracks in Concrete Roads and how to prevent them."]*



# CONCRETE COTTAGE BUILDING.

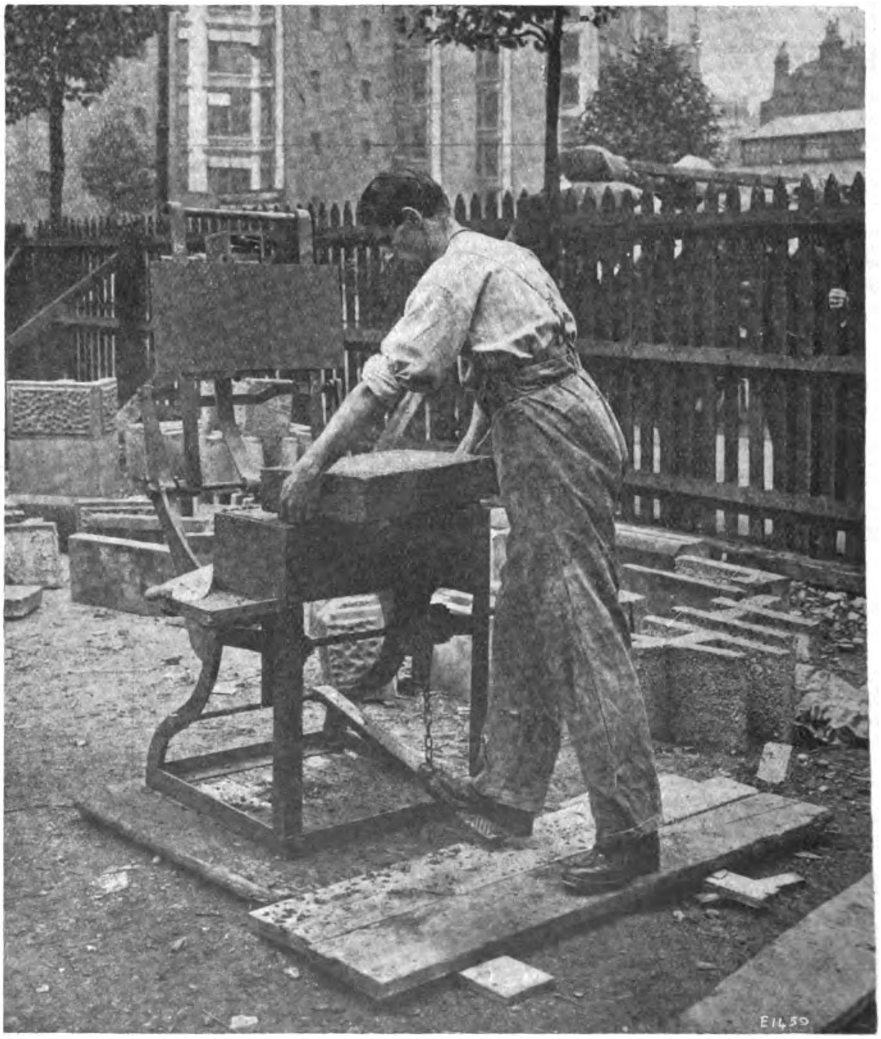
### A SIMPLE BLOCK-MAKING MACHINE.

The sudden development in the use of concrete as a cottage-building material has produced a diversity of systems, ranging from a portable machine, designed only for the manufacture of bricks or blocks requiring in their use no particular method of construction, to an intricate design in which the entire house is the unit produced. The disadvantage of the latter system is that, although it may tend towards standardisation and mass production, it does not permit of any variations to suit differences of taste or environment. One of the essential qualities for a successful system is adaptability. In most systems it is possible to trace some—perhaps unconscious—trend of thought which is responsible for their inception; thus in the simplest block-making machine it is that bricks are scarce, yet they are the traditional building unit; let us, therefore, make our concrete into brick form. This will account for one kind of machine. Another person, however, may argue that damp penetration in a house occurs to a large extent at the joints of the brick work; let us, therefore, have larger units and fewer joints. Thus a machine for the production of larger blocks is invented.

The Australia Concrete Block Machine Syndicate, Ltd., makes a machine which moulds blocks 24 in. by 12 in., varying from 2 in. to 5 in. in thickness. The machine is very portable and light, weighing only 4 cwt. It is, furthermore, extremely simple both in operation and design, having no complicated mechanical parts which are liable to damage.

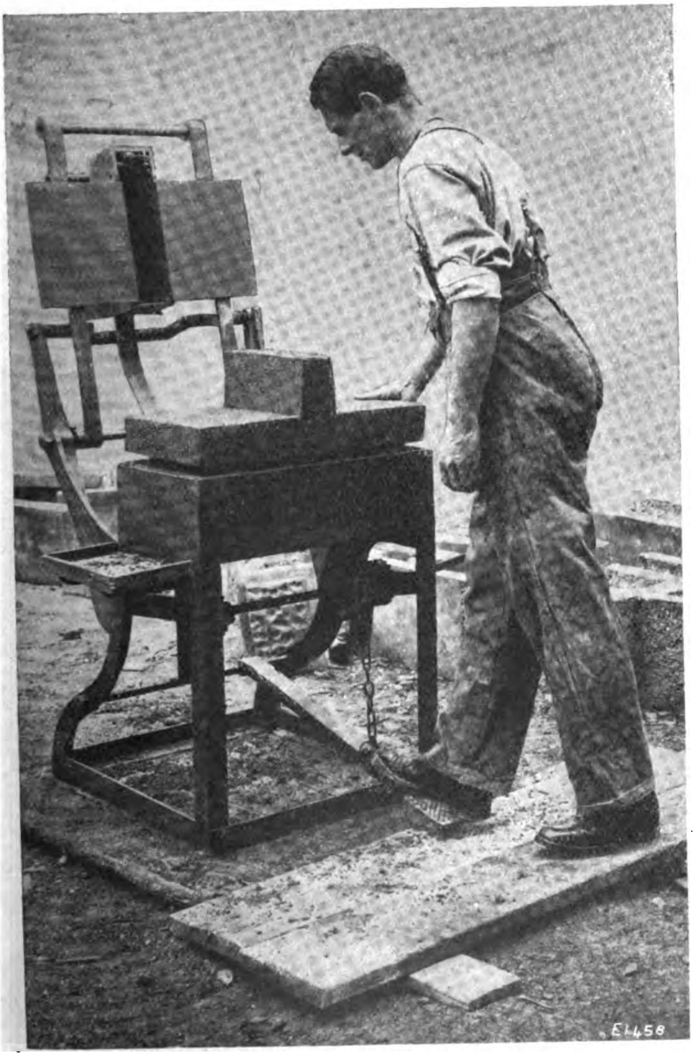
The blocks are moulded horizontally on pallets, thus they are made to the correct consistency, and no subsequent sprinkling—except in exceptionally hot weather—is required. The mixture is placed in the mould, at the bottom of which lies a pallet; it is then rammed by an automatic hand-worked rammer. The block is lifted from the mould on the pallet by a simple device actuated by the foot of the operator, which consists of a false bottom double rack, two gear wheels, a pulley and chain, axle and foot lever. The gear wheels and pulley are attached to the axle, the chain being fastened around the pulley and to the foot lever. By pressing the foot lever downwards the chain unwinds and revolves the pulley and gear wheels on which the rack works, thus forcing the false bottom and block from the machine. The block is then set out on its pallet to dry for about twelve hours; it is afterwards stood on end and the pallet released for re-use.

For the outside walls the blocks are T-shaped on plan, thus effecting a continuous yet well-bonded cavity, permitting of free circulation of air and requiring no metal ties. For partition walls an ordinary flat block is required, and by means of a simple adjustment to the hinged rammer these can be made from the same machine, as can also quoins, door and window jambs, mullions, and chimney flue blocks. By means of different pallets a variety of face effects can be obtained, such as chisel-dressed, hammer-dressed, vermiculated, tooled, pointed, with plain or drafted margins. Most of these, however, constitute an attempt to imitate stone work, and should therefore be eschewed by the careful designer. If concrete block-making is to take its place as a recognised building material it must do so without attempting to insinuate itself in the disguise of

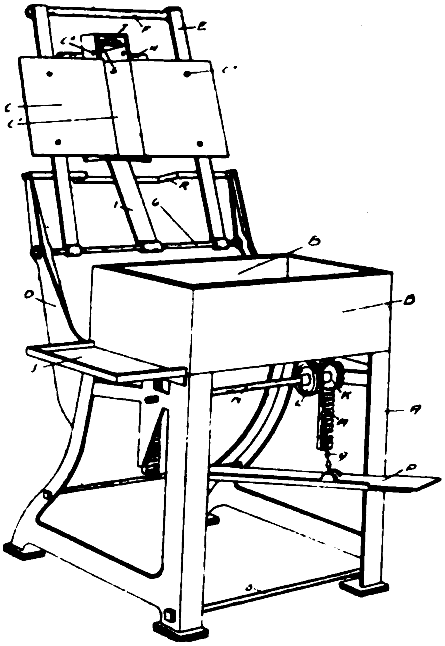


stone. And this, moreover, is by no means necessary, for concrete weathers into a variety of pleasant and characteristic surfaces and textures.

The method of making the blocks is extremely simple, although, of course, the greatest care must be exercised in choice of material and in mixing. For the plain block, the box is filled with concrete and the mechanical rammer brought down and raised. For the T-block the rammer is left down, and the flask mould in the centre of the rammer filled with concrete and rammed with a hand tamper and finished off with the T-nib mechanical rammer. When the whole is sufficiently compressed both rammers are lifted off in one motion. The apparatus is so designed as to afford particular protection to the corners and arrises, which otherwise are liable to break away.

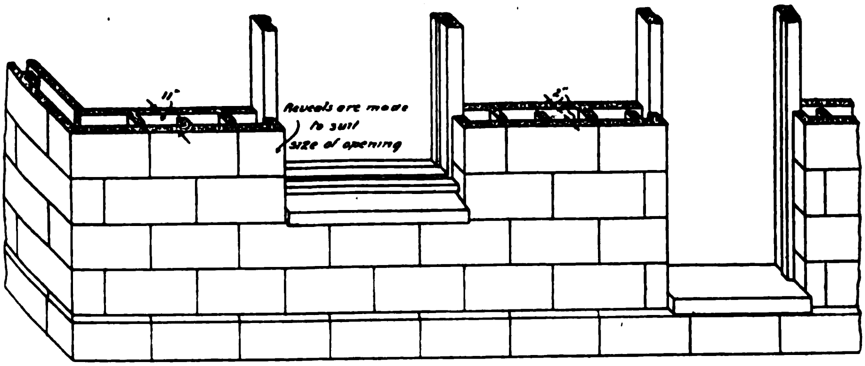


A—Legs.
B—Moulding Box.
C—Rammer Plate and T Section Mould combined.
D—Rammer Axle Stays.
E—Rammer Arms.
F—Rammer Handle.
G—Rammer Axle.
H—"T" Section Rammer Handle.
I—"T" Section Rammer Arm.



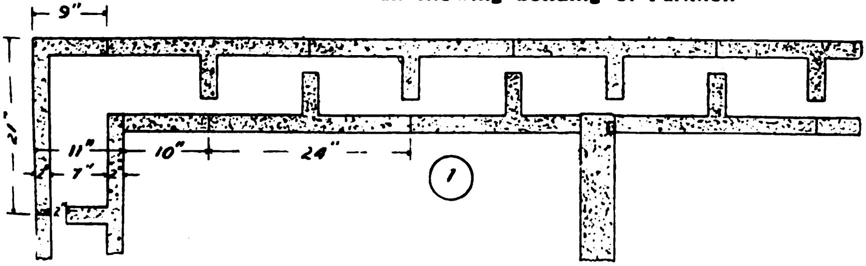
J—Shelf.
K—Cog Wheel.
L—Pulley.
M—Rack.
N—Main Axle.
O—Stay Bolt.
P—Foot Lever.
Q—Chain.
R—Rammer Support.
S—"T" Section Mouldin Box Door.
T—Catch for closing door.

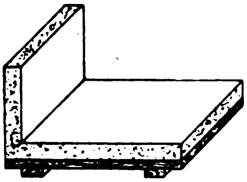
General View of the Australia Machine.



(Isometric) Showing Continuous Cavity Wall Bond

Plan of T Section Wall showing bonding of Partition





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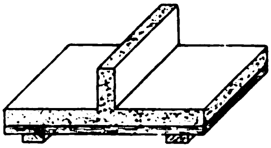
QUOIN ON PALLET



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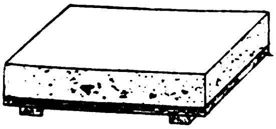
T SECTION BLOCK ON PALLET



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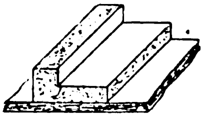
SLAB ON PALLET



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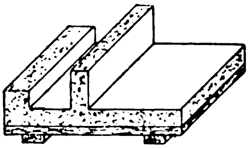
HALF-DOOR OR WINDOW REVEAL ON PALLET



⑥

DOOR OR WINDOW REVEAL ON PALLET.

Although with this machine it is possible to make blocks of special sizes by packing out the mould with wood, it is advisable to work to block dimensions. The walls should, therefore, be plotted out on paper before building, showing the exact position of door and window openings and any other special blocks.

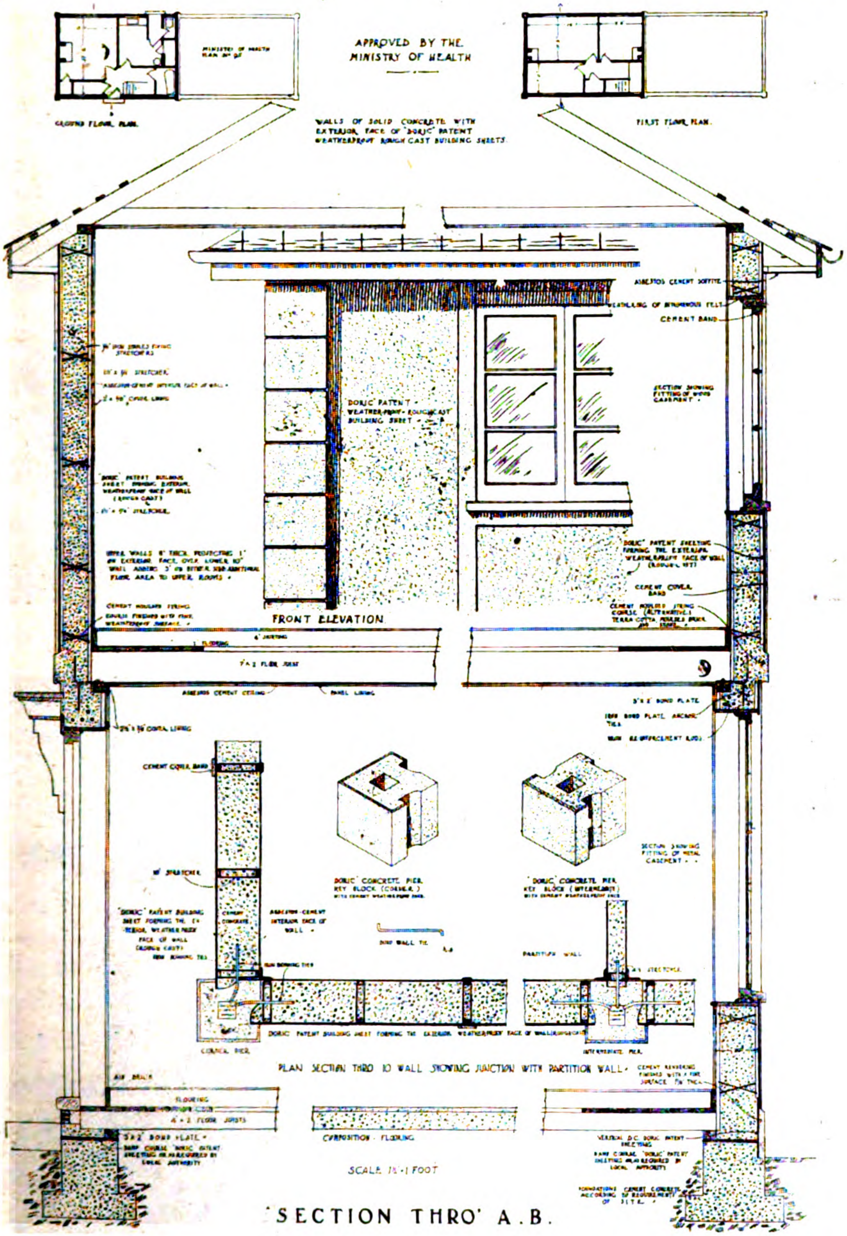
In the matter of cost, provided that suitable aggregate is at hand—and a variety of materials may be used for this purpose, such as ballast, gravel, scoria, crushed stones or granite—the blocks compare very favourably with brickwork. The cost of making 100 of the T-section blocks is stated to be 30s., and these are equivalent to 1,068 bricks. Partition slabs or breeze-blocks of a similar size are 25s. per 100. This, it need hardly be pointed out, is a great saving over brickwork, since London stocks cost more than 80s. per 1,000. A further saving occurs by reason of the fewer joints, which require only one-eighth the amount of mortar. The rate of daily output is estimated on one machine to be 350 faced blocks, or 450 breeze slabs. With regard to the speed of erection, it is difficult to give any very precise figure on account of the great discrepancy at present prevailing between potential and actual output. It is claimed that the blocks can be laid at a rate of 200 a day, and reckoning 100 blocks equivalent to 1,068 bricks, this would mean that blocks equalling about 2,136 bricks could be laid in a day. The output of the bricklayer is at present about 350 bricks.

Considerable success has been achieved in Australia by means of this machine, and its simplicity and adaptability should commend it to all who are dismayed at the present high price of bricks. It may be added that the only expensive item in connection with the machine, which costs £50, is the cast-iron pallets, but for those who are content with a simple plain-faced block this need be no deterrent, for wooden pallets—preferably of red pine—may be used for rough blocks, and for facing blocks a piece of flat tin placed on the wooden pallet is all that is required. Such pallets cost only one-tenth of those made of cast-iron. The surface of the outer wall may, if desired, be treated in a variety of ways, The machine is both simple and straightforward, free from unnecessary intricacies and embellishments, yet designed on scientific principles.

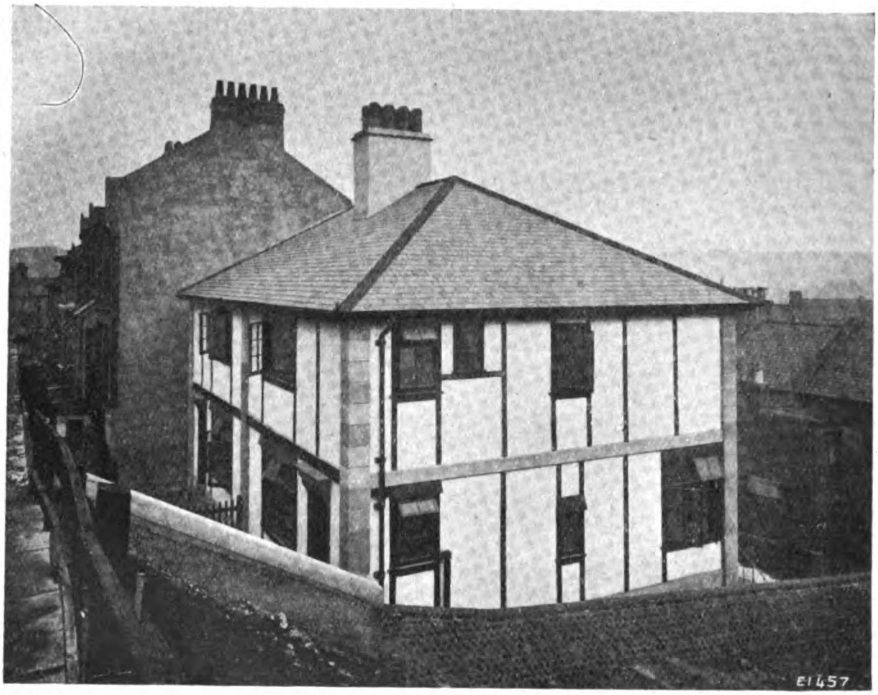
### CONCRETE HOUSES AT BRIGHTON.

It is both natural and desirable that the intending builder of a house, whether he be an architect, a building contractor, or a layman, hesitates before recommending or employing a new method of construction unless he has had ample opportunity to examine it, not only on paper, but projected into three dimensions. Before long almost every district in England will possess concrete houses of some kind to which those proposing to build, in whatsoever capacity, may refer. It is as yet impossible to pronounce a verdict in favour of any one particular system of construction ; theories and opinions are conflicting, and perfection, even if it were obtainable, would necessarily sometimes give way to expediency. Again, many systems depend for their efficiency upon some patent ingredient which time alone can test. Such a system is that known as the " Doric," which is the patent of the " Modern Building " Company, who erected some small houses in Kingsley Road, Brighton, in September, 1919.

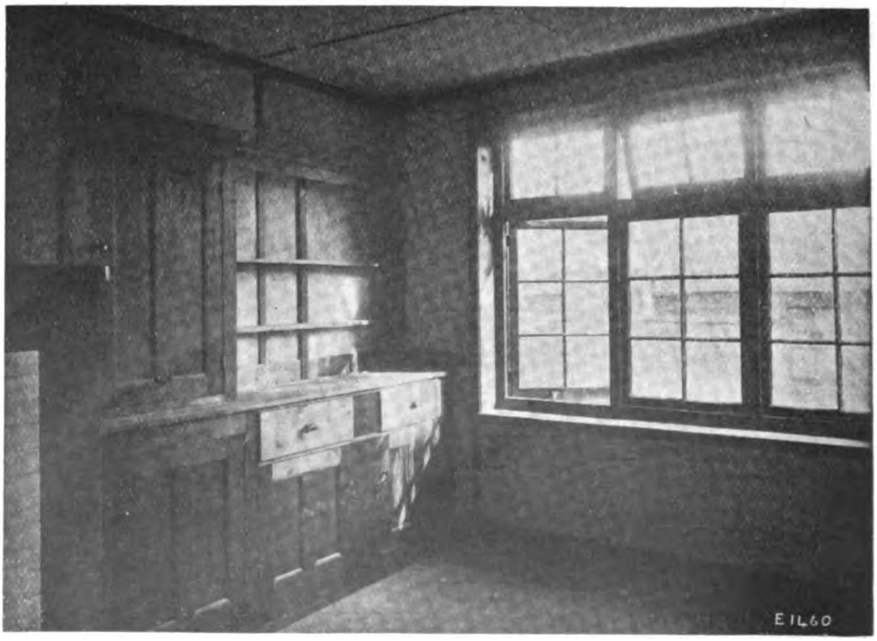
The form of the " Doric " construction is that of a monolithic reinforced concrete wall. The principle is that of concrete piers at intervals, between which is placed shuttering that forms an integral part of the structure. The piers, which are built at salient and re-entrant angles and at other intervals according to the design of the building, are made of hollow pre-moulded concrete blocks, and are specially keyed to take the shuttering and to make bond with internal partitions. They are subsequently filled with cement. The outside plane of the


GROUND FLOOR PLAN.
APPROVED BY THE MINISTRY OF HEALTH
FIRST FLOOR PLAN.
WALLS OF SOLID CONCRETE WITH EXTERIOR FACE OF "DORIC" PATENT WEATHERPROOF ROUGH CAST BUILDING SHEETS.
ASBESTOS CEMENT SOFFITE
CEMENT BAND
DORIC PATENT WEATHERPROOF ROUGHCAST BUILDING SHEET
SECTION SHOWING FITTING OF WOOD CASEMENT
CEMENT COVER BAND
FRONT ELEVATION
ASBESTOS CEMENT CEILING
CEMENT COVER BAND
"DORIC" CONCRETE PIER KEY BLOCK (CORNER)
"DORIC" CONCRETE PIER KEY BLOCK (INTERMEDIATE)
SECTION SHOWING FITTING OF METAL CASEMENT
PARTITION WALL
INTERMEDIATE PIER
CORNER PIER
PLAN SECTION THRO 10 WALL SHOWING JUNCTION WITH PARTITION WALL
COMPOSITION FLOORING
SCALE 1½"-1 FOOT
SECTION THRO' A.B.

Details of construction, Doric System.



Exterior view of completed house.



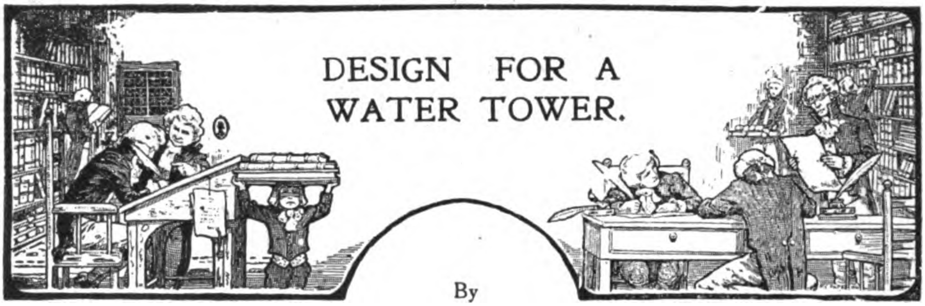
Living room.
HOUSES AT BRIGHTON ON THE DORIC SYSTEM.

wall is made of patent building sheets which are manufactured by a special process of cement and asbestos fibre, reinforced with netting and weather-proofed with a bituminous composition which is claimed to be impervious. Another form of patent sheeting forms the inside plane to the wall. These sheets are held in position by wooden stretchers, connected through the thickness of the wall by iron ties. These ties are left in the wall as reinforcement. The concrete is poured into the cavity between the sheets. At intervals iron ties are built into the piers ; these bond with the liquid concrete.

At first-floor level the wall is reduced in thickness and it is overhung, and the wall plate is layed on the space thus formed. To the floor joists are attached iron bars bent upwards and downwards so as to anchor into the wall. Thus where these run across the building they act as ties, and tend to stiffen the whole structure. The construction of the upper part of the wall is continued in the same way above the first floor, but reduced in thickness from 10 in. to 8 in. in the case of the houses at Brighton. A cement-moulded string course is formed where the upper part of the wall projects ; it should be possible, however, to carry the wall up without this overhang, which, if it constituted an essential part of the structure, would necessarily impose a very severe limitation upon the designer of the house. Similarly, the joints in the patent sheeting are covered by a vertical cement fillet ; if this were unavoidable it would constitute a great disadvantage. But there seems no reason why the joints should not be well lapped and the whole wall treated with rough-cast or cement. In the same way the joints of the inside sheeting, which occur over the wood stretchers, are covered by wood strips, thus dividing the wall surface into panels. This treatment might not always be desired ; the alternative would then be to paper the walls. The wood stretchers occurring at regular intervals form permanent fixings in place of plugs or coke-breeze.

The accommodation in the houses at Brighton is that of the Ministry of Health's "B" type, viz., a parlour, living room, scullery and larder on the ground floor, with three bedrooms, a bath and w.c. on the first floor. If the houses prove successful, and this depends for the most part upon the impervious quality of the outside sheetings, there is no reason why the system should not be adapted to larger houses. The cost of the cottages, assuming a level site, would be approximately £700, which shows a considerable saving over a similar-sized house constructed in brickwork. The houses have been approved by the Ministry of Health in connection with State-aided housing schemes, upon which the Government grant loans over the full period of 60 years.

The erection of these houses is an interesting and enterprising experiment, and only by continuing such experiments will concrete take its rightful place as a recognised material for cottage building, and a foolish wish, such as the one recently expressed in a contemporary, that concrete houses may soon crumble to the dust from which they were made, as if bricks were not equally composed of that ubiquitous material, be a thing of the past.



# DESIGN FOR A WATER TOWER.

By

**FRANK H. HEAVEN, A.R.I.B.A.**

*The design of the Water Tower here described was the subject set for the award of the Grissell Gold Medal and Prize of £10 10 0 by the Royal Institute of British Architects in their annual competitions for 1915, but owing to the war these competitions were cancelled until 1920, and the results have only recently been made known.—ED.*

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In designing the water tower any medium could be selected by the competitors, and the successful author worked entirely in reinforced concrete, other competitors choosing reinforced concrete with brick facing, reinforced concrete structure with steel tank, and dressed stone.

The data upon which the winning design was based is that recommended by the Second Report of the Joint Committee upon Reinforced Concrete together with the following :—

| | |
|---|---|
| Capacity of tank required | 50,000 gall. |
| Actual capacity .. | 51,000 gall. |
| Diameter of tank .. .. | 33 ft. |
| Depth of water line .. .. | 10 ft. |
| Weight of water .. .. | 10 lb. per gall. |
| Capacity of water .. .. | 6¼ gall. per cu.ft |
| Working stresses on concrete— | |
| In compression in beams | 600 lb. per sq. in. |
| In compression in columns | 600 lb. per sq. in. |
| In shear in beams .. .. | 60 lb. per sq. in. |
| Working stresses in steel— | |
| In tension .. .. | 16,000 lb. per sq. in. |
| In shear .. .. | 12,000 lb. per sq. in. |
| In compression .. | 15 times the stress in surrounding concrete. |

| | |
|---|---|
| Coefficients of elasticity in compression— | |
| Steel (Es) .. .. | 30,000,000 lb. per sq. in. |
| Concrete (Ec) .. | 2,000,000 lb. per sq. in. |
| Ratio $\frac{Es}{Ec}$ .. .. | 15 |
| Wind pressure .. .. .. | 30 lb. per sq. ft. |
| Mixture of concrete .. | 1 part Portland cement<br>2 parts washed sand.<br>4 parts broken aggregate. |
| (To pass defined meshes for various positions) | |

## THE DESIGN.

*The Dome.*—The dome is 6 in. thick and has a diameter of 33 ft., a rise of 5 ft. and a radius of 29 ft. 9 in. It has been designed to carry, besides its own weight and wind pressure, an accidental load equal to 36 lb. per sq. ft., plus 50 per cent. for shock. No reinforcement is required to resist a maximum total compression at base of 42,400 lb. (or 1,425 lb. per ft. of circumference), but to resist a maximum radial thrust or hoop compression of 3,500 lb. on a plane 9 ft. 6 in. long by 20 in. wide, reinforcement consisting of four ½ in. dia. rods at 5 in. centres is provided. No reinforcement is required to resist bending longitudinally between the above radial reinforcement.

*The Tank.*—The external wall of tank is 8 in. thick with variable reinforcement.

The tank, which is circular, has a domed top with pierced parapet, panelled exterior with moulded base and cornice, and a flat bottom. The parapet is 4 in. thick and reinforced with ⅜ in. dia. bars at 4 in. centres. The cornice has similar reinforcement.

Piercing the centre of tank is a shaft 7 ft. in diameter, giving direct access from the ground below to the outside of domed roof, etc.

A gallery 2 ft. 6 in. wide runs round the centre shaft in the tank above the water line, for inspection purposes and working of water valves, etc., and is 2½ in. thick reinforced with radial rods at 7 in. centres.

Light and air are admitted to tank through small apertures in walls above the water level.

*Tank Supports.*—Supporting the tank is a series of circular beams numbered 1, 3 and 4 in the diagram *Fig.* 1; the ends of the internal and external circular beams are supported by cantilevers off the main piers; the ends of the central circular beam being supported by the piers themselves. Radial beams and cantilevers numbered 2, 5 and 6 in *Fig.* 1 complete the structure, together with the floor slabs A, B and C.

The floor slabs of tank are 7½ in. thick with a maximum tensile reinforcement of ·567 sq. in. in the centre width and a minimum of ·105 sq. in. at the sides.

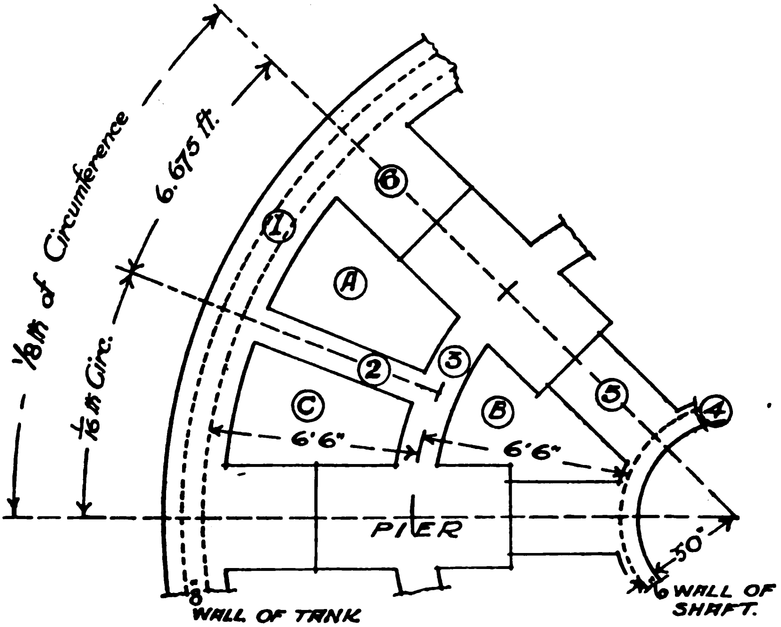


FIG. 1. FLOOR OF TANK.

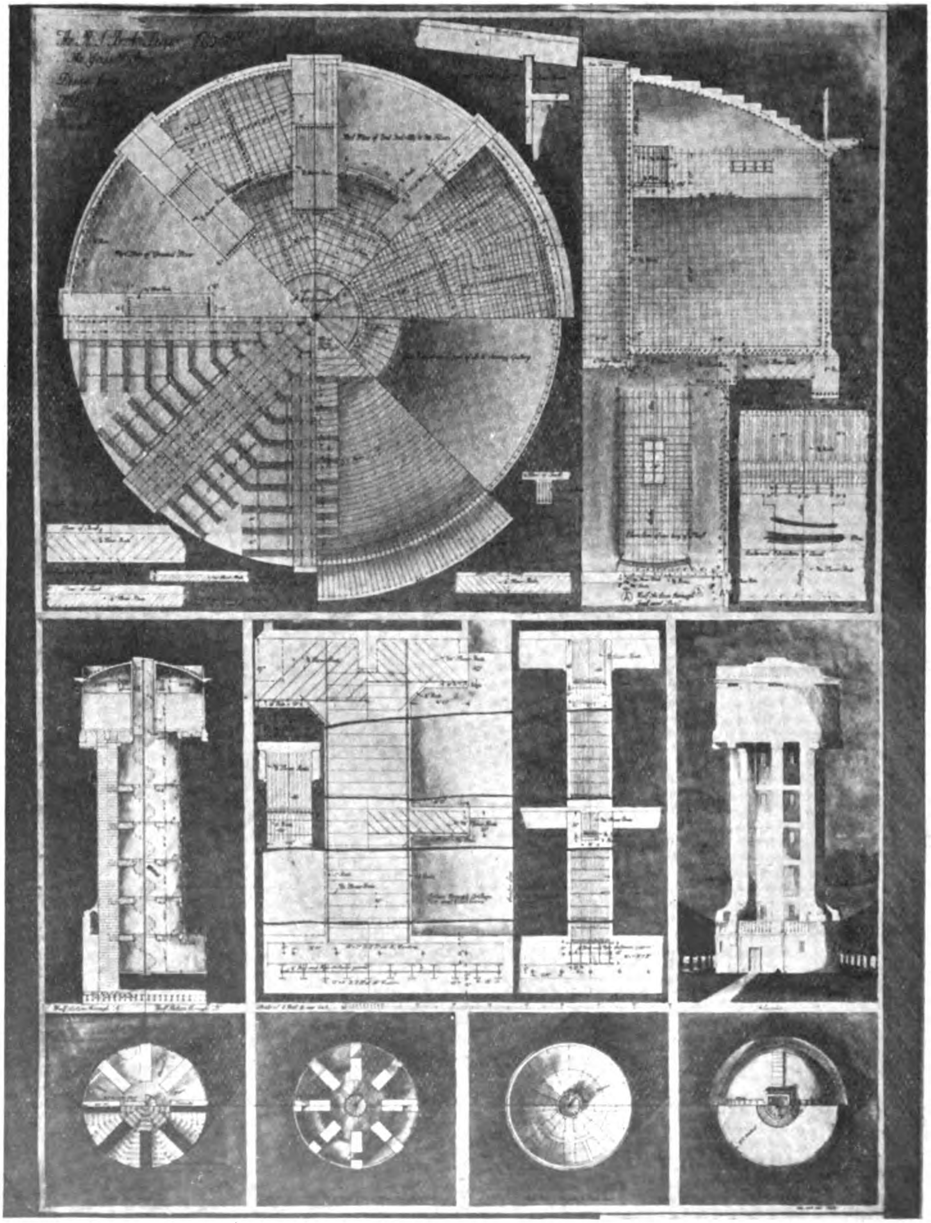
A graphic method of ascertaining the variable reinforcement required throughout the cross section of slabs was employed and is illustrated by the diagram *Fig.* 3, in which—

L = length of slab, in this case 6·675 ft.

1–0 = area of tensile reinforcement required for centre 12 in. width of slab set out to any convenient scale.

1–2, 2–3, 3–4 = 12 in. width of slab at right angles to length L.

Then, since the stress strain curve is assumed to be parabolic, the areas of reinforcement for the whole slab on this line of cross section can be obtained by completing the parabola and dropping down vertical ordinates at the points 2, 3 and 4, which, when measured by the same scale as 1–0, give the area of tensile reinforcement required for those widths.



R.I.B.A. Grissell Medal: Design for a Concrete Water Tower by Mr. F. H. Heaven.

*The Piers.*—The tank is carried upon eight main piers or shafts with a thin screen wall closing in the interior and the tower thus obtained is divided up into five stories or floors, lighted by small windows in each bay. The piers are tied in at each storey level by the circular beams supporting the floors. The screen wall to lower or ground floor is brought out to the face of the piers. The first floor forms a roof over ground floor and also serves as a balcony between the piers with a pierced parapet, similar to that surmounting the dome, around the circumference.

The eight main piers are rectangular on plan and designed not only to resist the total compressive stresses but also the tensile stress due to wind pressure, etc., and are calculated for 10 ft. lengths (height between floors) as follows :—

| Size. | Reinforcement when subject to internal bending. | | Reinforcement when subject to external bending. | |
|---|---|---|---|---|
| | Tensile. | Area of each shear member. | Tensile. | Area of each shear member. |
| 38 in. by 72 in. | 8·9567 sq. in. | ·0412 sq. in. | 17·955 sq. in. | ·0765 sq. in. |

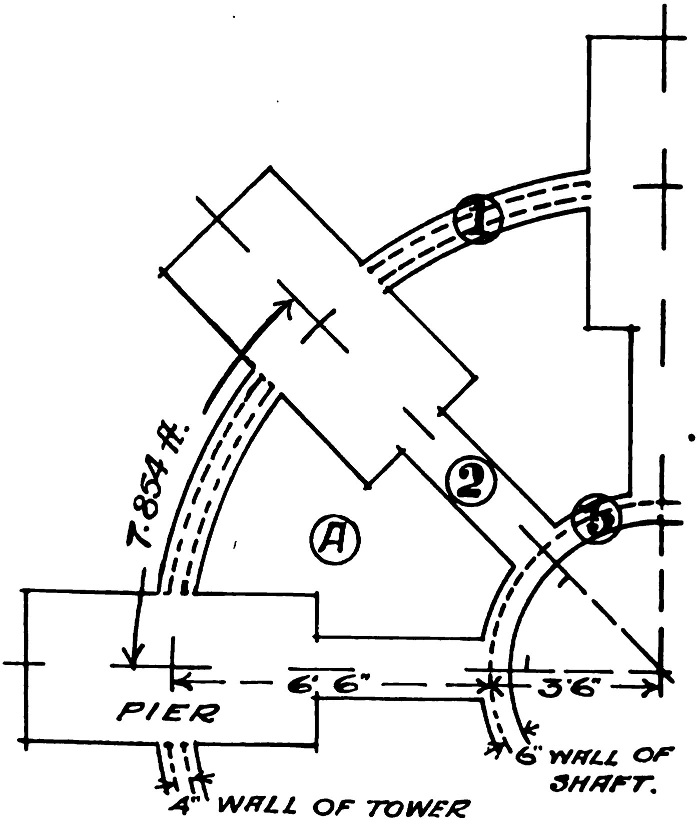


FIG. 2. FLOORS OF TOWERS.

*Floors.*—The storey floors between tank and ground are supported by two circular beams numbered 1 and 3 in diagram *Fig.* 2, and a cantilever numbered 2. The floor slab A is 3½ in. thick and has a maximum reinforcement at centre of ·243 sq. in. and a minimum reinforcement of ·030 sq. in. at sides; the variable reinforcement across slab being found graphically as before described.

The external portion of the first floor, which acts as a roof to the ground floor, is carried by the external screen wall and a circular beam between the piers, which latter is 10 in. by 15½ in. with tensile reinforcement equal to ·9922 sq. in. and each shear member equal to ·0428 sq. in. The floor-roof slab is 4½ in. thick, reinforced the short way with a maximum reinforcement of ·324 sq. in. in centre and a minimum reinforcement of ·2 sq. in. at sides; and the long way with a maximum of ·218 sq. in. and a minimum of ·075 sq. in. ascertained as before described.

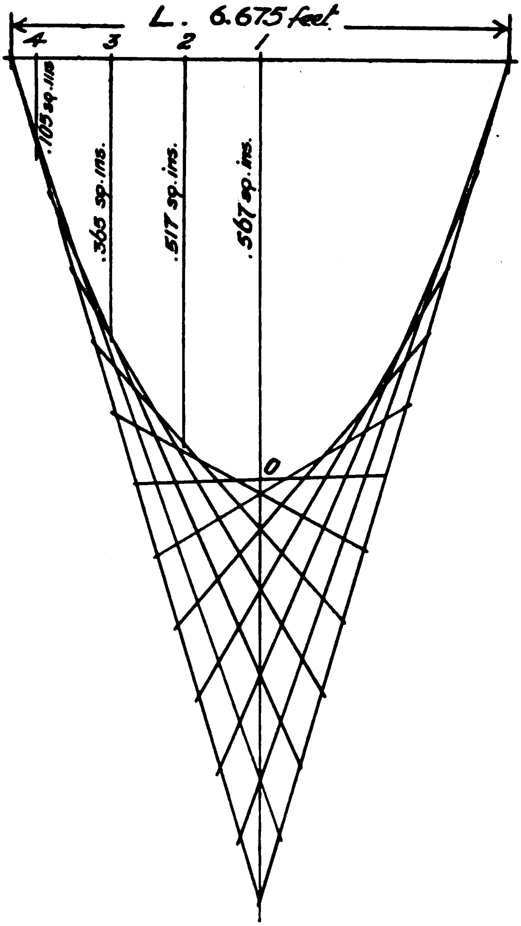


FIG. 3. GRAPH FOR ASCERTAINING SLAB REINFORCEMENT.

*Screen Walls.*—The external screen walls of tower are 4 in. thick reinforced vertically with a maximum reinforcement of ·2835 sq. in. in centre and a minimum reinforcement of ·075 sq. in. at sides, and horizontally with a maximum of ·2835 sq. in. in centre and a minimum of ·105 sq. in. at sides.

The base screen wall is also 4 in. thick with equal reinforcement vertically and horizontally as that of the vertical in the upper screen walls.

The wall of internal shaft passing through the water tank is 6 in. thick and reinforced horizontally with ·182 sq. in. per 12 in. of height and vertically with ·243 sq. in. per 12 in. of width.

*Grillage.* — The grillage foundation, which is circular on plan, projects 6 ft. beyond base of piers and is 4 ft. thick reinforced with British standard beams, as follows:—Top layer, five 18-in. by 7-in. at 8-in. centres; bottom layer, eleven 12-in. by 5-in. at 18-in. centres.

*Staircase.*—An iron spiral staircase running up through the centre gives access to each floor, to outside of dome, and to gallery in tank.

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# THE BEHAVIOUR OF REINFORCED CONCRETE COLUMNS UNDER FIRE TEST.

## Part I.

By WALTER A. HULL, U.S. Bureau of Standards, Pittsburgh, Pa.*

*The following is an abstract from two articles which appeared in the "American Architect." Our illustrations have also been reproduced from that periodical.—ED.*

THE fire-resistive qualities of concrete columns have now been under investigation by the Pittsburgh laboratories of the U.S. Bureau of Standards for approximately two years. During this time a large number of tests on full-sized columns have been conducted and sufficient data accumulated to permit the drawing of some rather definite conclusions.

The present investigation by the Bureau of Standards was designed secure, with a minimum number of tests, of full-size columns, some definite information as to the effect of the kind of aggregate, the kind of reinforcement and the form of the column, on the behaviour of concrete columns under fire, including such data as the temperatures attained in the reinforcement and in the interior of the column, as well as the strength of the column while the highest temperatures existed.

Nearly all of the columns were made 18 in. in diameter, if round, or 16 in. square. Round columns, 12 in. in diameter, were made from one aggregate, with one type of reinforcement. In all columns having reinforcement, the latter was placed so as to leave a thickness of 1½ in. of concrete outside the steel. The effective diameter in spirally reinforced columns was taken as the horizontal distance between centres of the hooping. Vertical rods in columns having only vertical reinforcement were placed at the same distance from the outside of the column as the vertical rods in hooped columns, the effective diameter being assumed to be the same as that for spirally reinforced columns of the same size. In the square columns, the vertical rods were placed at the same distance from the surface of the concrete as in the round ones and the effective area was taken as that portion within a square with its sides located $\frac{5}{32}$ in. beyond the outside of the rods to correspond with the criterion followed in figuring the effective area of the spirally reinforced round columns. All columns were made 8 ft. 9 in. long.

The gravel used was the washed river gravel commonly used in the Pittsburgh district for making reinforced concrete.

The limestone aggregate, as furnished from the quarries, was fairly well graded, the sizes ranging up to about ¾ in. 'In all the columns, the Pittsburgh river sand was used. One proportion, 1 : 2 : 4, was maintained throughout the series. The age of columns ranged at the time of testing from six to nine months.

The test apparatus consisted essentially of a gas-fired furnace which is provided with a loading equipment so that a load can be kept on the column during test and that the column can be tested for strength, while still hot, if desired. A 600,000 lb. load can be applied without difficulty.

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* This article is based on two papers by Mr. Hull, presented before the American Concrete Institute. Part I deals with the data contained in the first paper, and Part II with that in the second.

Temperature is measured, both in the furnace and in the interior of the column by means of iron-constantan thermocouples and a Leeds and Northrup potentiometer indicator.

In all tests, the working load of the column is kept on the column during the fire test. If the column withstands the 600,000 lb. load, it is permitted to cool, transferred to the 10,000,000 lb. machine and tested in that.

The firing of the furnace is regulated, as closely as possible, to conformance with the tentative standard fire-test curve, which is shown in *Figs.* 1 and 2.

That portion of the test data which is calculated to give, in condensed form, the characteristic performance of the different kinds of columns, has been arranged in tabular form, as presented in the following Tables I. to V. :—

TABLE I.

18 in. cylindrical columns.
Thickness of concrete outside the steel, 1½ in.
Reinforcement : 2 per cent. vertical, 8 round rods, ¾ in. diam. 1 per cent. spiral, $\frac{3}{16}$ in. diam. 2 in. pitch, 2 spacers.
Effective area concrete, 168·7 sq. in.
Area vertical steel, 3·53 sq. in.
Effective area column, 172·2 sq. in.
Working load, 141,500 lb.

| | Column number. | Maximum load, lb. | | Maximum stress, lb. per sq. in. | Maximum temperature at end of 4-hour fire test, ° C. | | |
|---|---|---|---|---|---|---|---|
| | | Without fire test. | At end fire test. | | In steel. | Midway between steel and centre. | At centre of column. |
| Gravel concrete .. | 1 | — | —* | — | 950 | 410 | 240 |
| | 2 | — | —* | — | 1,050 | 460 | 290 |
| | 3 | — | 197,000 | 1,145 | 945 | 355 | 210 |
| | 5 | 1,090,000 | — | 6,340 | — | — | — |
| Limestone-concrete .. | 17 | — | —* | — | 520 | 240 | 120 |
| | 18 | — | —* | — | 560 | 180 | 100 |
| | 20 | 1,187,000 | — | 6,890 | — | — | — |

* Column No. 1 failed, under working load, at end of 3 hr. 45 min. Column No. 2 failed, under working load, at end of 4 hr. 15 min. Column No. 17 loaded, at end of 4 hr. fire test, to 600,000 lb. without failure. Tested later, cold, in large testing machine. Maximum load, 820.000 lb. Column No. 18 tested in the same way as No. 17. Maximum load, 916,000 lb.

TABLE II.

18 in. cylindrical columns.
Thickness of concrete outside the steel, 1½ in.
Reinforcement : 2 per cent. vertical, 8 round rods, ¾ in. diam. Ties, ¼ in. diam., 12 in. centres.
Effective area concrete, 168·7 sq. in.
Area steel, 3·53 sq. in.
Effective area column, 172·2 sq. in.
Working load, 99,750 lb.

| | Column number. | Maximum load, lb. | | Maximum stress, lb. per sq. in. | Maximum temperature at end of 4-hour fire test, ° C. | | |
|---|---|---|---|---|---|---|---|
| | | Without fire test. | At end of 4-hr. fire test. | | In steel. | Midway between steel and centre. | At centre of column. |
| Gravel concrete .. | 7 | — | —* | — | 1,010 | 310 | 210 |
| | 8 | — | 235,000 | 1,365 | 630 | 270 | 130 |
| | 10 | 803,000 | — | 4,660 | — | — | — |
| Limestone-concrete .. | 21 | — | 370,000 | 2,150 | 580 | 240 | 100 |
| | 22 | — | 375,000 | 2,180 | 580 | 230 | 100 |
| | 24 | 739,000 | — | 4,290 | — | — | — |

* Column No. 7, after 5-hour fire test, was loaded to failure. Maximum load, 185,000 lb.

TABLE III.

18. in. cylindrical columns.
Thickness of concrete considered as protective material, 1½ in.
Reinforcement, none.
Effective area, 180 sq. in.
Working load, 81,000 lb.

| | Column number. | Maximum load, lb. | | Maximum stress, lb. per sq. in. | Maximum temperature at end of 4-hour fire test, ° C. | | |
|---|---|---|---|---|---|---|---|
| | | Without fire test. | At end of 4-hr. fire test. | | 2¼ in. from surface. | 5⅝ in. from surface. | At centre of column. |
| Gravel Concrete .. .. | 12 | — | 130,000 | 835 | 1,070 | 450 | 205 |
| | 15 | 657,000 | — | 3,650 | — | — | — |

TABLE IV.

16 in. square columns.
Thickness of concrete outside the steel, 1½ in.
Reinforcement: 2 per cent. vertical, 4 round rods, 1 in. diam. Ties, ¼ in. diam., 12 in. centres.
Effective area concrete, 156 sq. in.
Area steel, 3·14 sq. in.
Effective area column, 159·14 sq. in.
Area steel, 3·14 sq. in.
Working load, 92,000 lb.

| | Column number. | Maximum load, lb. | | Maximum stress, lb. per sq. in. | Maximum temperature at end of 4-hr. fire test, ° C. | |
|---|---|---|---|---|---|---|
| | | Without fire test. | At end of 4-hr. fire test. | | In steel | At centre of column. |
| Gravel concrete .. | 25 | — | 160,000 | 1,005 | 775 | 160 |
| | 26 | — | 132,000 | 830 | 995 | 165 |
| Limestone-concrete .. | 29 | — | 375,000 | 2,360 | 660 | 100 |
| | 30 | — | 385,000 | 2,420 | 630 | 100 |
| | 32 | 810,000 | — | 5,090 | — | — |

TABLE V.

12 in. cylindrical column.
Thickness of concrete outside the steel, 1½ in.
Reinforcement: 2 per cent. vertical, 4 round rods, ⅝ in. diam. 1 per cent. spiral, ¼ in. diam., 2½ in. pitch, 2 spacers.
Effective area concrete, 60·87 sq. in.
Area vertical steel, 1·23 sq. in.
Effective area column, 62·1 sq. in.
Working load, 50·850 lb.

| | Column number. | Maximum load at end of 4-hr. fire test. | Maximum stress, lb. per sq. in. | Maximum temperature at end of 4-hour fire test, ° C. | | |
|---|---|---|---|---|---|---|
| | | | | In steel. | Midway between steel and centre. | At centre of column. |
| Gravel concrete .. | 33 | 71,000 | 1,145 | 690 | 560 | 480 |

It is seen, from an inspection of the tables, that the poorest showing was made by those gravel concrete columns which had both vertical and spiral reinforcement. On the other hand the best showing was made by columns of the same type but with the limestone aggregate. The reason for this rather remarkable contrast between different columns of the same size and having the same kind of reinforcement is found in the physical behaviour of the different concretes under fire. With slight variations the observations made on the gravel concrete columns, Nos. 1, 2 and 3, were as follows:—After approximately 30 mins. of firing, cracks began to appear in the surface of the concrete. The nature of the cracking was similar to that which is observed in columns of this type when tested cold, just before the final failure. The appearance of the column, at this stage of the fire test, was that of a column that was failing or about to fail. In reality, it appears to have been actual failure, but failure only of the concrete covering outside the spiral. After this action started its process was very rapid; cracks lengthened until they intersected other cracks, thus dividing the outer concrete up into large pieces of slabs, which gradually separated from the rest of the column, so that after approximately one hour of firing slabs would begin to fall, exposing the spiral reinforcement and the load-bearing portion of the concrete to the direct heat of the furnace.

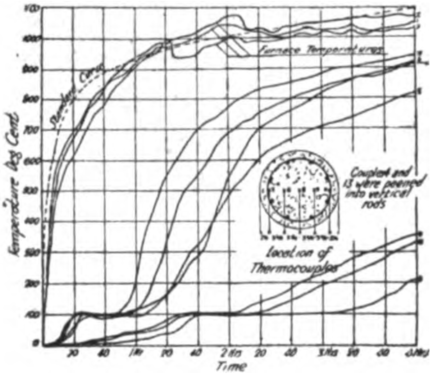


FIG. 1.
Col. 3. 18-in. Gravel Concrete Column with spiral and vertical reinforcement.

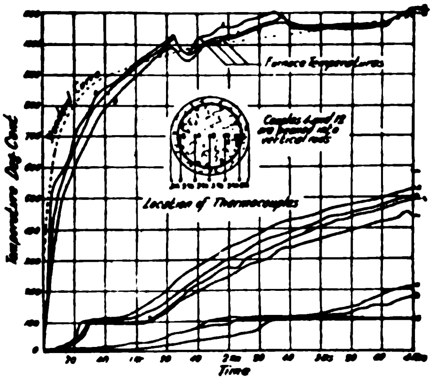


FIG. 2.
Col. 17. 18-in. Limestone Concrete Column with spiral and vertical reinforcement.

The falling of these broken portions of the outer concrete was a rather slow, gradual process, individual slabs hanging from the top or standing from the bottom of the column for some time after they had separated to such an extent that the end near the middle of the column took out some inches from the solid part of the column. However, after one hour of testing, the load-bearing portion of the column would be partially exposed and by the end of the second hour a very large portion of the length of the load-bearing portion of the column would be completely exposed, so that after the first hour the column proper was only partially protected and after the second hour it had practically no protection at all.

The progress of the temperatures within the columns under these conditions is seen in *Fig.* 1.

The comparison with the temperature shown in *Fig.* 2 for column 17 is significant. If we compare the temperature condition of these two columns at the end of the four-hour fire test, it is found that in column 3 the temperatures recorded at the depth of the steel ranged from 820° to 940° C. and those in column 17, at the same depth, were between 440° and 530° C. Temperatures at a depth midway between the steel and the centre of the column show the same tendency for these two columns, though at this depth the contrasts are naturally somewhat less marked. The effect, however, is seen even at the centre of the columns, the temperature at the centre in column 17 being approximately 100° C., as compared with 210° at the centre of column 35. It is evident from the results of the compression tests made after the four-hour fire tests that in column 3 not only the steel but the load-bearing concrete as well had lost strength very seriously, for the results of the test of column 15 shown in Table III. indicate that the load-bearing concrete in column 3, if uninjured, should have been good for approximately 450,000 lb., without any reinforcement.

*Gravel Concrete Columns.*—In all gravel columns of this series there was a marked tendency for the outer concrete to break up early in the fire test, and for the resulting slabs and fragments to separate and fall off, exposing the load bearing portion of the column. The effect of this process, in the most extreme cases, is to strip the load-bearing column of its insulation, early in the fire test, with the result that comparatively high temperatures are reached in the steel and in the interior of the column. This spalling is most active in the columns having spiral reinforcement. Round columns with vertical reinforcement, with ties every 12 in., suffered much less from spalling than those with spiral reinforcements.

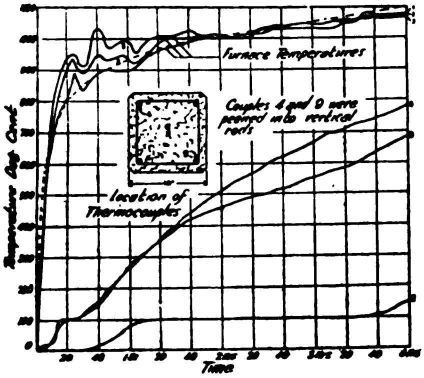


FIG. 3.
Col. 25. 16-in. Square Gravel Concrete Column with vertical reinforcement.

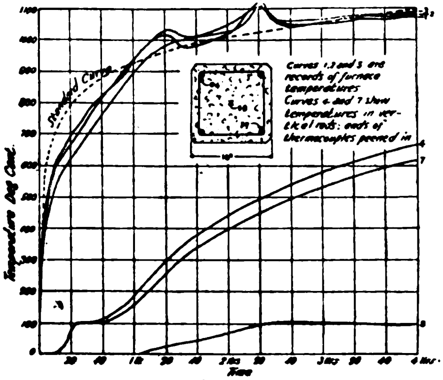


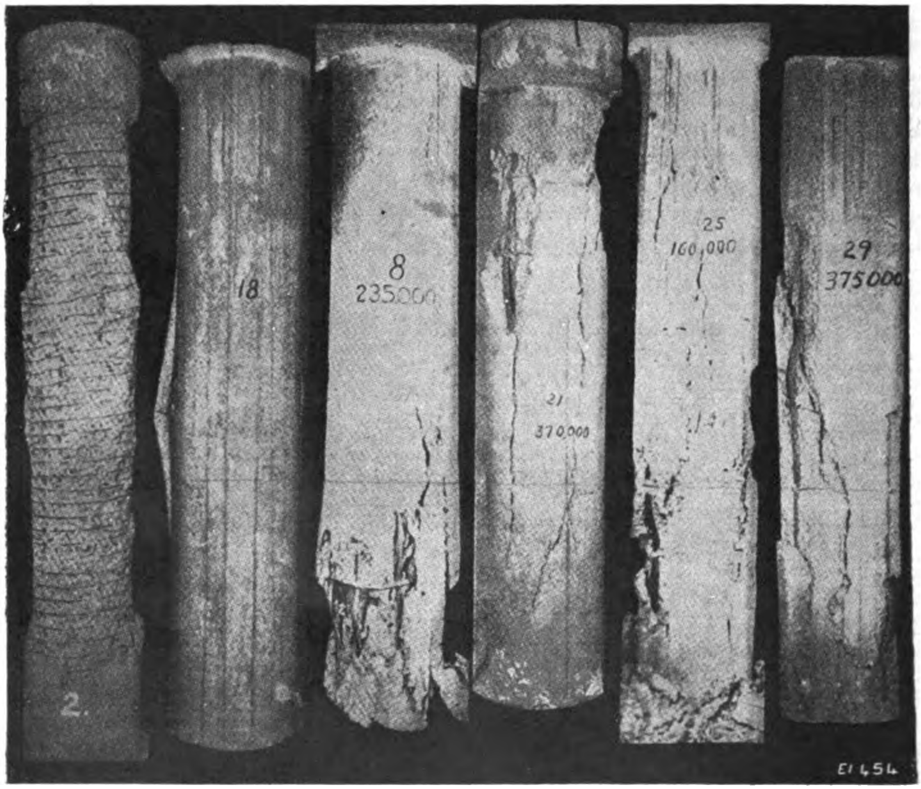
FIG. 4.
Col. 29. 16-in. Square Limestone Concrete Column with vertical reinforcement.

Square columns, vertically reinforced, spalled badly. A round column with no reinforcement showed an intermediate behaviour between that of the round columns with spiral and those without. Strength tests at the end of the 4-in. fire tests showed that gravel concrete columns with spiral reinforcement had retained from less than 15 to approximately 18 per cent. of the strength of the duplicate column tested without exposure to heat. A round column with vertical rods and no hooping had retained approximately 30 per cent. of the strength, square columns from 16 to 20 per cent. and a plain column approximately 23 per cent.

These unfavourable results with a gravel concrete are similar, in a general way, to those which have been observed, at various times, in laboratory heat tests and in fires in concrete buildings.

The expansion behaviour of quality marks it as a material which would be likely to cause trouble in concretes in which it formed a large part of the aggregate, which is the case in most American gravels.

There is strong evidence that the peculiar behaviour of the gravel concrete in these column tests is due to expansion ; yet the Pittsburgh gravel is not made up of pure quartz pebbles. It contains a few quartz pebbles along with a much larger proportion of pebbles of sandstone and of other harder rock, all appearing to be high in quartz. Inasmuch as most of the American gravels have an exceedingly high quartz content, it would seem, from the information available at present, that any gravel aggregate should be investigated before being used, unprotected, in important work requiring fire resistive properties in the concrete.



Col. 2. Gravel concrete failed in 4h. 15m. Concrete came off early in test.
Col. 18. Limestone concrete After 600,000 lb. at end of 4h. fire test.
Col. 8. Gravel concrete. Round.
Col. 21. Limestone concrete. Round
Col. 25. Gravel concrete. Square.
Col. 29. Limestone concrete. Square.

Inasmuch as gravel concrete is almost an economic necessity in certain localities, a further series of tests were planned, and have been in progress for some time, providing various types of outer shell protection to the gravel concrete interior. The results of these tests are encouraging.

The behaviour of the limestone concrete under the action of high temperatures is interesting and extremely important. In many localities a prejudice exists against the use of a limestone aggregate. The tests data are favourable to this material, and in the light of the results given in the tables and curves, the architectural profession should lend its efforts to extend the use of limestone aggregate in localities in which it is available.

(*To be continued.*)

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# HOUSING EXHIBITION AT OLYMPIA.

*As was to have been expected, the "Ideal Home" Exhibition, held at Olympia last month, contained examples of many of the new methods of small house construction which have been approved by the Ministry of Health as suitable for use in connection with housing schemes. In the cottages erected, concrete was the prevailing material used; in fact, with the exception of timber-frame houses, which are only suitable for rural areas, and the official exhibits of the Ministry of Health, which were of brick carried up to about 4 ft. 6 in. from ground level and assembled together in an annexe, the Exhibition only contained one example of a brick house. When it is considered that at the present time the cost of housing schemes is being cut down to the last penny, and that the speed with which the houses can be erected is a very big factor in the choice of material, the manner in which concrete dominated this Exhibition can only be taken as testimony to the economy of this kind of construction and the rapidity with which it can be carried out. Another point to be remembered is the very short space of time allowed for the erection of the exhibits, and this was undoubtedly the factor which practically ruled out brickwork. This was the first occasion on which so many different systems of concrete cottage construction, built to actual size, have been brought together for inspection, and the fact that most of the exhibitors, in addition to complete cottages, showed sections of walling, blocks, etc., added to the interest from the practical point of view. Although many systems were on view, there was very little that was actually new or has not been described before in this journal, and on this occasion we propose to confine attention more especially to such methods or improvements that have not come under general notice.—ED.*

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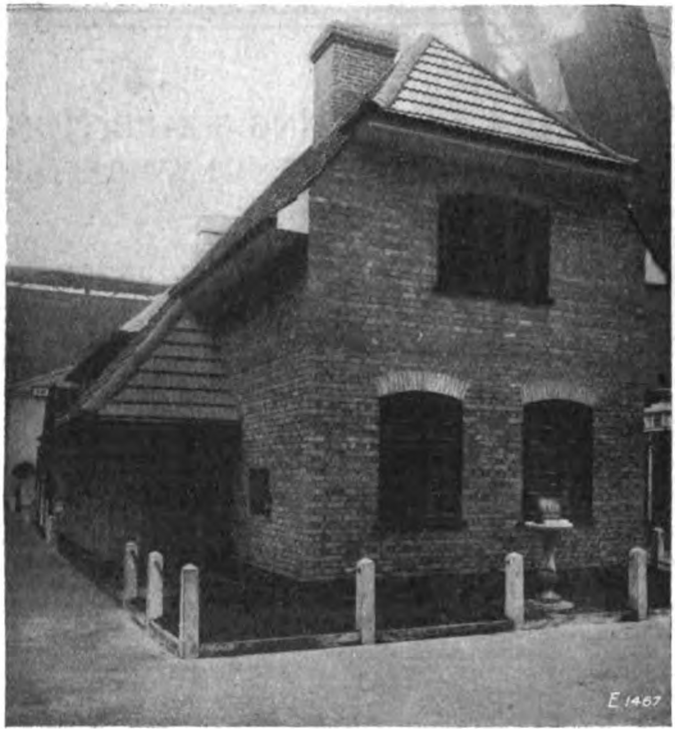
## CONCRETE COTTAGES.

ONE of the principal objections raised against the use of concrete for houses in the past has been its appearance, which, it was urged, was not so picturesque as brick. Objections are invariably raised against innovations no matter in what direction they are made, and in this case the prejudice is probably to be traced to the proposition made some years ago to turn out flat-fronted, " box-with-lid-on " type of cottages by erecting shuttering to cover whole streets at a time, and pouring concrete therein. The result would certainly have been ugly and uninteresting, but nowadays different ideas are held as to the design of cottages for the working classes. The types shown at the Exhibition, with half-timbered elevations, and blocks moulded to represent stone, both chiselled and panelled, were very effective and would not be out of place in any locality.

Perhaps the most interesting cottage was shown by MESSRS. VICKERS, LTD. This small house had every appearance of a red-tiled brick cottage, with a pitched roof, and it was only on very close inspection that the fact could be discovered that both the bricks and tiles were made of concrete. The whole of the building and its fittings were manufactured by the Vickers Co. and its associated companies. The concrete bricks are of the same size as standard bricks—viz., 9 in. by 4½ in. by 3 in.—made with the Vickers portable brick machine. The mixture used is six parts sand to one part cement, and an advantage over ordinary bricks is that they are uniform in shape and quality, thus allowing of a larger number to be laid in a given time. If suitable aggregate is available on the site the cost of transport is also eliminated, a no inconsiderable item in the cost of building at the present time. The roofing tiles are concrete interlocking tiles, waterproofed and pleasingly coloured with a special cement. According to the amount of oxide used, they can, of course, be coloured any desired tint. The partition walls are built with both breeze concrete slabs and fire-resisting bricks.

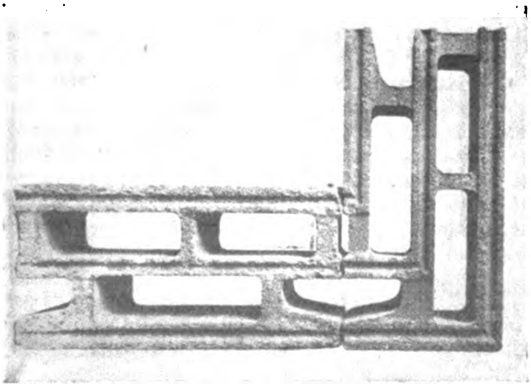
The SIMPLEX CONSTRUCTION CO., LTD., undertakes the erection of houses of any material, and on this occasion exhibited a bungalow built with steel framing and " Silab " slabs and sheets. These sheets and slabs are manufactured from a silico



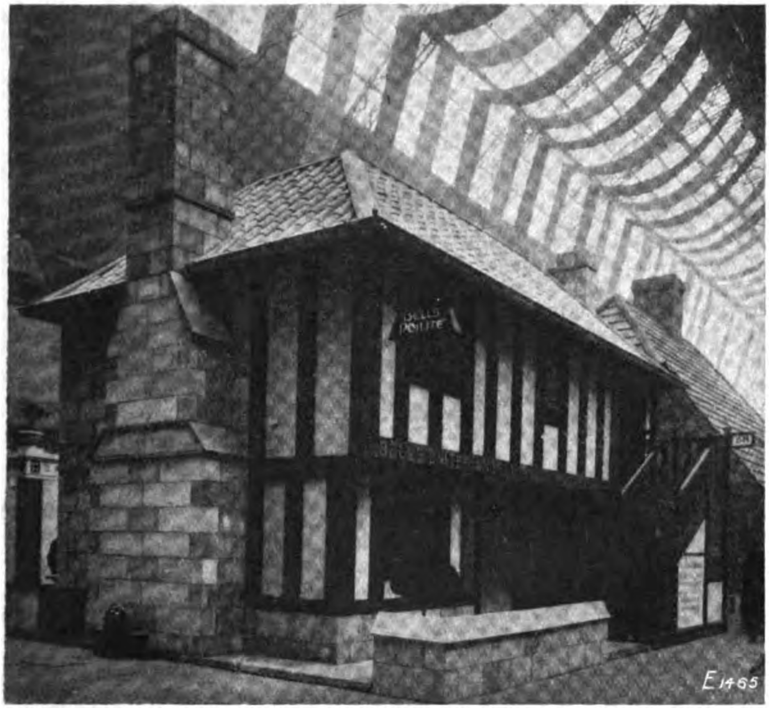
THE VICKERS CONCRETE BRICK COTTAGE.

fibrous cementitious material. The houses are constructed of interlocking steel joists on concrete foundations. The steel skeleton is made rigid, and on battens fixed to the joists slabs are attached outside and one-inch sheets inside, leaving an air-space of from 1½ in. to 3 in. The slabs are made in various colours and require no plaster; it is claimed that the walls can be papered or distempered immediately they are erected. "Silab" concrete blocks were also shown. These blocks are of the cavity type, with the air-spaces so arranged that a continuous air chamber is formed throughout the walls. The internal face is of a porous nature, while the exteriors are waterproofed and moulded to resemble panels, rock, pebble-dash or rough-cast finish.

MESSRS. S. THORNELEY, MOTT & VINES, LTD., showed specimens of their "Aero-block" system of concrete wall construction. This block has two or more air-spaces, which are arranged so that an imaginary straight line crossing the wall and the plane of the row of air-spaces would pass through at least one air-space. Consequently, no part of the wall is solid right through, as is shown in our illustration. The blocks are made 11¾ in. by 6¼ in. by 6 in. and 11¾ in. by 8 in. by 6 in., with two and three cavities respectively. This firm also showed the "Ironite" brand cement for flooring and "Ironite" Portland cement slurry or grouting for waterproofing concrete or brickwork.



"AERO"-BLOCK WITH TWO AIR SPACES.

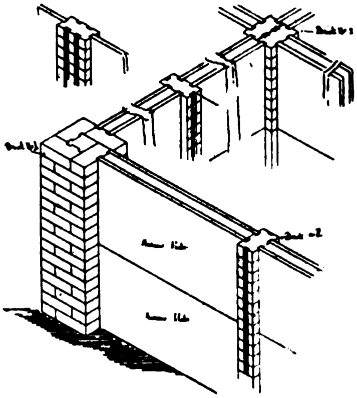


COTTAGE BY BELL'S UNITED ASBESTOS CO., LTD.

The cottage erected by MESSRS. BELL'S UNITED ASBESTOS CO., LTD., was of particularly striking design, resembling a half-timbered stone cottage with red tiles. The walls are formed of "Hurcon" concrete and asbestos slabs and "Poilite" asbestos sheeting, and the roofs of red-coloured concrete pantiles. The inside faces of the concrete blocks are hollowed out so that when laid in the form of a cavity wall a continuous air-space is provided. The inner and outer slabs form practically two hollow blocks, with the exception that the slabs are set slightly apart so that the wall is in no part solid right through. In this cottage both steelwork and piers are eliminated, the "Poilite" sheeting being held in position by fillets on the timber work.

On this stand was also shown the "Lovell" brick for the formation of piers for use in connection with concrete slab construction; a pair of cottages built on this system was illustrated in our January issue. These bricks are the same size as ordinary stocks, and are made with grooves in one face of the width of the slab which they are intended to take. The bricks are built in piers at corners, doorways and windows, and with standardised slabs greatly simplify construction. For cottage construction, two slabs are used, but the brick piers can be widened as required to take three or more slabs if required for heavier construction, such as factory or warehouse building.

The stand of MESSRS. W. ALBAN RICHARDS & CO., LTD., contained an example of walling in which a combination of brick and concrete is used. Concrete slabs, 2 in. thick, are used



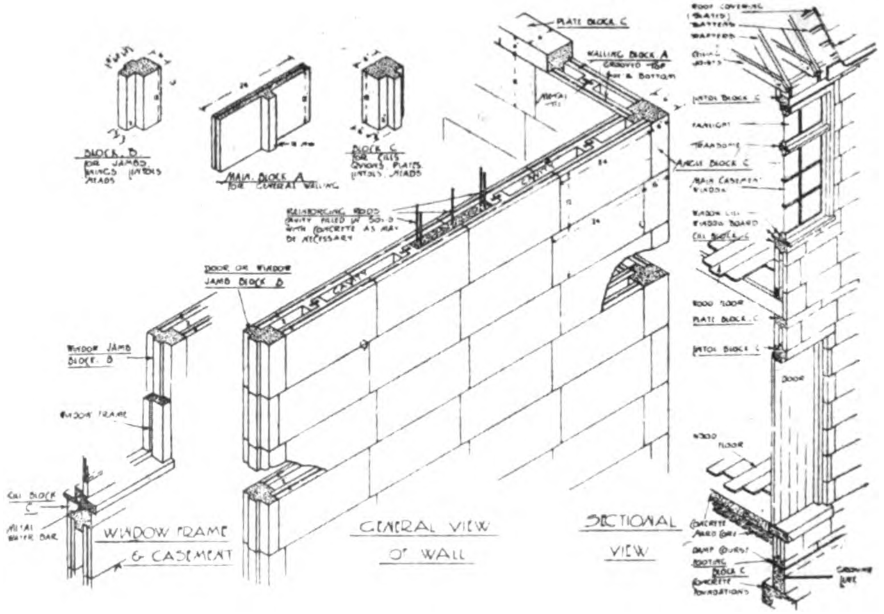
"LOVELL" BRICK AND CONCRETE SLAB CONSTRUCTION.

for the interior and bricks laid flat for the exterior, with a cavity between. The two walls are tied together with galvanised iron strips. In this way a brick exterior is obtained with a minimum of brickwork, with a resultant economy in cost and labour.

Messrs. Dorman Long & Co., Ltd., exhibited one of the steel-frame and concrete type of houses built by the firm for the Dormanstown housing scheme. This system of construction was fully described in our last issue.

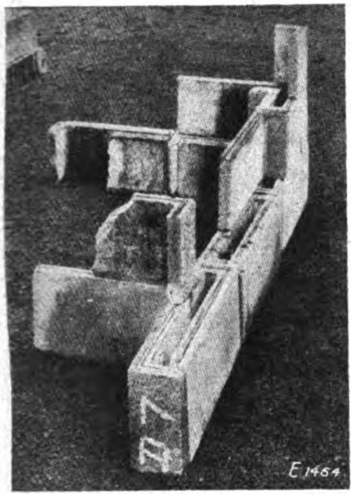
The " Unit " system of concrete cottage construction was illustrated and described in connection with the housing scheme being carried out at Braintree, in our issue for November last. The Unit Construction Co., Ltd., has further large orders in hand, including a contract for about one thousand houses in one district. The firm's stand at the Exhibition contained samples of the " Unit " system of walling and many photographs of work being carried out.

The Economic Building Corporation, Ltd., uses the cavity wall system of construction, and exhibited a partially-built cottage in which the constructional details could be examined. The blocks are 24 in. by 12 in. by 2 in. thick for the general run of walling, and have a projecting piece 2 in. deep at the centre of the inside face. When laid in position, these flanges fit side by side and form piers 4 in. wide throughout the height of the wall. At each course, these piers are tied together with strips of metal. The angles of the walls are formed with solid corner pieces, which fit into the cavities in the wall in either direction. In this system the concrete blocks are standardised ; only three types and sizes of blocks are used, and the houses are erected on the " unit " principle, the walls being bonded at each course.



"Economic" System of Walling.

Another system of cavity walling was shown by the Bonding Block Constructional Co., Ltd. In this case the slabs are L-shaped, and when in position form an oblong with an air-space between. When grouted together, the cross-pieces form piers and bridging-pieces, and no ties or bolts are used. These piers are staggered when the blocks are laid and thus the air-space is continuous throughout



Bonding-Block Hollow Wall Construction.

the height and width of the wall. The slabs are made 2 in. thick, 27 in. by 12 in. on the face and with cross-pieces 6¾ in. deep, and 2½ in. thick, 27 in. by 12 in. on the face and 7½ in. cross-pieces, for the construction of 6¾ in. and 7½ in. walls respectively. The company does not contract for the erection of buildings but is prepared to supply the blocks or machines for their manufacture.

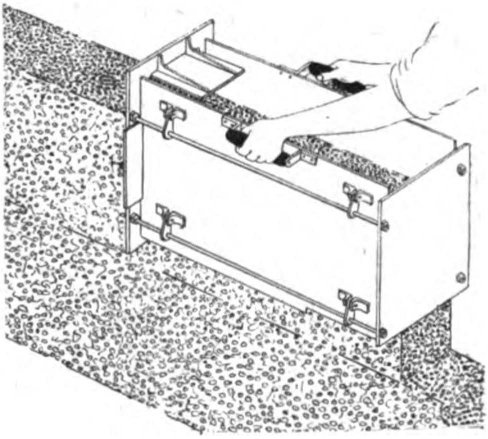
The products of the Self-Sentering Expanded Metal Works, Ltd., are intended to eliminate the use of wood shuttering in the construction of reinforced concrete work. "Self-Sentering" is a ribbed expanded metal reinforcement for flooring, and will retain wet flooring without the use of boarding. "Trussit" is a corrugated expanded-metal reinforcement specially designed for concrete walling. When encased in 1½ in. plaster, this material has been approved by the Ministry of Health for forming the outer walls in houses built on the cavity-wall system. "Herringbone" is intended to replace wood laths, and is claimed to be fire-resisting and permanent. It is made from 28, 26 and 24 gauge sheet into sheets 8 ft. by 18 in. "Herringbone" is also stated to be cheaper than wood lath and quicker to fix and plaster.

The machinery side of the Exhibition was rather poorly represented. Messrs. Winget, Ltd., had the most representative display, and showed types of their well-known batch mixers adapted for both petrol and electric drive. These mixers are mounted on wheels, and are very compactly designed; they are made in various capacities. 'Winget" pressure and hand block-making machines were also on view. The block of three cottages, illustrated herewith, designed by Mr. H. E. Farmer, F.R.I.B.A., are of "Winget" construction, and shows the artistic effect obtainable by an understanding of the material.

"Winget" Cottages at Sedbury—Mr. H. E. Farmer, F.R.I.B.A., Architect.

One of the simplest hand block-making machines on the market, that made by the Australia Concrete Block-Making Machine Co., was also shown, and is fully described elsewhere in this issue.

A mould which has not been exhibited before was shown by the Scruby-Harkness Building Mould Co., Ltd., of Harlow, Essex. This mould aims at economy in the use of both material and labour, in that it is intended for the construction of walls in monolithic courses without the use of shuttering. The mould is made of steel throughout, and one is sufficient for the construction of any length of wall. The method of operation, which is explained by our illustration, is as follows:—In starting the wall, a detachable plate is inserted in the open end of the mould (the left in the illustration) and the concrete poured in and punned. The removable end is then taken out, and by a simple movement of the rods at the sides, the side-plates are freed from contact with the concrete and the mould drawn along until the open end is within a few inches of the end of the finished block. When being again filled to make a further section of walling, the few inches of concrete from the previous block which has been left projecting into the mould is broken down and mixed in with the new material, thus forming a continuous slab. This operation is repeated until the course is complete. In the upper courses, the mould rests on the lower course by a flange inside and on the completed part of the same course by the flange shown. These flanges are fixed so that the bottom of the mould projects a short distance below the top of the completed course. The completed courses are kept damp until the next course is applied, in order that the concrete may bind and form a monolithic structure. One disadvantage is that the mould does not permit of continuous vertical reinforcing rods being used, although, of course, short lengths could be inserted at intervals as the work progresses. There is no difficulty in the use of horizontal reinforcement between the courses. The moulds are two feet long, and are made in various widths to suit either solid or cavity walls. It is claimed that one man can perform thirty operations per hour, equivalent to upwards of fifty feet of walling of the height of the mould, and that a house with five rooms and the usual offices can be built for £300. Two bungalows have been erected with unskilled labour on this system, which have received the approval of the Ministry of Health. The mould is sold complete for £10, or may be had on hire.

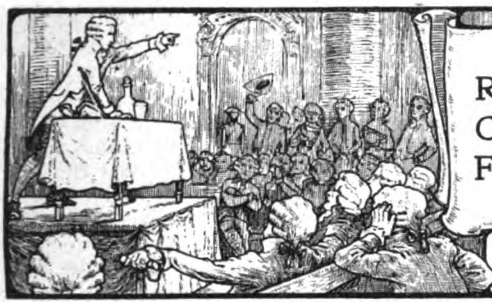


Mould in Use—Releasing. Sides receded outwards, allowing Mould to be drawn along to continue the wall.

The **British Lean Co.** exhibited their machine for the manufacture of concrete blocks with two or three cavities. These machines are for hire on a royalty basis, and it is claimed that with one machine two unskilled men and a boy can turn out from 800 to 1,000 blocks per day of eight hours. The blocks measure 12 in. by 6 in. by 6 in. with two air-spaces, and 12 in. by 8 in. by 6 in. with three air-spaces.

### METALLISATION OF CEMENT.

A new feature in the treatment of cement was shown on the stand of **Mr. Francis F. Proctor**, of 7, Vondel Street, Amsterdam. This is a patented process for the metallisation of concrete and all materials containing cement, such as plastered walls, and cement and asbestos sheets. By a chemical action on the cement a hardening coating is formed, and at the same time the surface can be coloured, either plain or varied, as desired. It is claimed that these colours are fast and very durable, and that they penetrate one-eighth to one-sixth of an inch into the surface of the material; it is also stated that the compressive strength of the material is increased by 50 per cent. Asbestos sheeting, garden ornaments, and bas-reliefs treated with this process were shown, and the small ornaments treated to resemble bronze are almost indistinguishable from that metal at a casual glance; and some of the vases coloured in rich, warm tones closely resemble pottery. The inventor proposes to float a company to exploit the patent in this country, and is prepared to consider applications from those interested with a view to granting licences to use the process.



# RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

*It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.*

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### *THE CONCRETE INSTITUTE.*

## THE ATTRITION OF CONCRETE SURFACES EXPOSED TO SEA ACTION.

By J. S. OWENS, M.D., Assoc.M.Inst.C.E.

*The following is an abstract from a Paper read at the ninety-first ordinary general meeting of the Concrete Institute on January 22nd. The author dealt with his subject under the following three heads :—(a) The mechanism of attrition ; (b) The factors governing rate of attrition ; (c) Methods of reducing attrition.*

### MECHANISM OF ATTRITION.

It is not very easy to define the word attrition exactly or to draw the line between what we may regard as being covered by this expression (which implies a rubbing away) and cutting or breaking away of pieces from a surface. In fact, the distinction between cutting, breaking, and attrition is more or less an artificial one and depends upon the scale of the action rather than upon any inherent differences.

In the case now under consideration—*i.e.*, the attrition of concrete surfaces by sea action, we are concerned with a brittle material which under stress breaks into fragments, but the need for the stress to exceed a certain limit still remains. A case of a somewhat similar kind is that of the wear of road surfaces, but it differs from the one we are now considering in certain important particulars to be referred to later.

We can now easily realise that water alone is unlikely ever to be able to cause the wear of concrete surfaces. However big the wave which strikes them, or however rapid the current, the resulting pressure will be diffused and will be below the limit necessary to cause fracture of the surface at any point. This is apart from solution or chemical action and assumes sufficient structural stability to resist the general pressure. When, however, such a wave or current carries boulders, stones, or sand with it, the conditions are very different. The boulders striking the surface with a high velocity cause sudden intense local pressure which results in crushing to fragments the particles of aggregate on the surface. Following the blow the water thoroughly washes the injured part, removing all loose pieces and leaving everything ready for the next blow. This washing effect is very important, and differentiates the mechanism acting here from that on road surfaces ; in the latter case, the broken fragments remain more or less where they are, and form a pad of dust or mud which deadens the subsequent blows received. In the case of structures exposed to sea action, the surfaces are usually more or less vertical, and the process of removal of the fragments caused by blows is thus facilitated.

It will be well now to consider more closely the factors which determine the force of the blows which, when repeated often enough, result in the wearing away of the surface of sea walls, piles, and other concrete structures exposed to sea action.

The stress due to a force or the pressure per unit area is a function of the force, $F$, and of the area, $A$, over which it is spread, and is numerically equal to $F/A$. It is this stress which is the important thing, since unless it exceeds a certain limit, depending on the material, no harm is done.

Considering first the factors which determine $F$, or the total force of a blow from a boulder or stone driven against a concrete surface by wave action. The governing factors are :—(1) The velocity of impact, (2) the weight or mass of the stone, (3) the degree of compression of the stone or surface permitted by the material under the blow.

The velocity of impact depends, for a given sized stone, upon the violence of the waves. A heavy sea can produce a pressure of up to about 3½ tons per square foot when it strikes the flat surface of a wall. This pressure is not of itself sufficient to crush concrete, but it is capable of driving forward heavy boulders. A boulder acted on thus by a breaking wave may strike a wall or pile with a high velocity. Calling this velocity $v$ ft. secs. and the weight of the boulder $W$, the energy of the moving boulder on striking will be $Wv^2/2g$. The force of the impact goes up therefore as the square of the velocity and directly as the weight of the boulder. It must be kept in mind, however, that the force referred to now is the total force and not the stress which, as pointed out before, depends upon the area of contact between the boulder and the face struck. It can, however, be seen how very rapidly the force increases as the violence of the waves increases, since it goes up as the square of the velocity.

The importance of the size or weight of the boulder is also great, especially as it is one of the things which we can sometimes control, for example, by dumping small shingle on a beach which is covered by coarse boulders. It is not, however, very often that this factor can be controlled in practice.

Dense stones do not appear to have an elastic limit, in the usual sense, but deformation is proportional to load up to a point of rupture.

Considering now the effect of compression of the boulder or surface struck under the blow. Suppose a boulder of $W$ lb. weight strikes a concrete face, with a velocity of $v$ ft. secs., the energy is $Wv^2/2g$. If there is a compression $= x$ and a maximum pressure $= F$ upon the wall, then, assuming that $F$ varies steadily from 0 at the moment of impact to $F$ when the boulder is brought to rest, which is not strictly speaking true, the average pressure $= F/2$, and the work done $= Fx/2$, which must be $= Wv^2/2g$, or

$$F = \frac{Wv^2}{gx}$$

For the present purpose this may be regarded as sufficiently correct.

It appears, therefore, that the capacity to undergo some distortion without fracture is an important factor in resisting blows. The distortion may be an elastic one or plastic one; provided resistance is offered to deformation, either tends to reduce the maximum stress. Of course, this is common knowledge, and is the principle underlying the use of springs for vehicles, buffers and similar appliances.

In this connection attention may be drawn to the fact that pieces of timber left flush with a concrete face exposed to attrition by sea action are found after a time to project beyond the surface of the surrounding concrete, especially if the end grain is on the surface. This point will be referred to later when considering remedies for attrition.

In the present case we may neglect any movement of the structure under the impact so that the whole energy of the blow is available for producing deformation of the surface. Should the limit of strength of the material be exceeded, permanent injury occurs, and in the case of concrete this usually implies fractures of the surface layer.

It may be taken that when shingle or stones are driven against a concrete surface, the resistance to rupture of the surface is always exceeded at some part, as for example, when a projecting grain of sand or piece of aggregate receives the whole force of a blow. It is not, therefore, of much interest to consider the effect of impact when the resistance of the concrete is not exceeded, but the importance of absorbing the energy of the blows by permitting some deformation of the surface has been dwelt on as suggesting the possibility of a remedy for attrition along these lines.

Much of the concrete which is exposed to sea action round our coasts is made with flint aggregate and sometimes faced with flint boulders. It will, therefore, be of interest to consider shortly the peculiarities of flint fractures under percussive blows. Flint is a form of colloidal silica and behaves very much like glass under impact. When a chip is broken off its bed by a sharp blow, both chip and bed exhibit what is known as a conchoidal fracture—that is, a smooth curved surface with concentric waves or ridges having the point of impact as centre. These waves result from the transmission of an elastic vibration due to the blow which passes rapidly through the flint causing rupture at the surface where the stresses become greater than the flint will resist. This form of fracture is seen when a chip or piece is broken by a sharp blow from the free edge of a flint or a piece of glass.

When, however, a blow is received on a flat surface of flint a very curious form of fracture sometimes results. In this the flint is broken away from a smooth cone, having the point of impact as apex. The surface of the cone then represents the shearing surface. If the blow is not heavy enough to make a complete fracture, more or less circular cracks develop, surrounding the point of impact.

It will be noted that in this discussion of the mechanism of attrition the effect of percussion alone has been dealt with. There is no doubt that this is the prime factor in bringing about the wear of concrete surfaces. It is practically the only way in which the sea can attack a surface—*i.e.*, by driving against it the sand or shingle carried by the water; there is not much opportunity for rubbing, although under some conditions a certain amount of this takes place. When waves are running in obliquely to the line of the foreshore, shingle or boulders carried by the waves against a wall have an alongshore component. When a stone strikes the surface of the wall obliquely there will be a certain amount of rubbing as well as percussion, as the stone will glance off against the wall. When it is remembered that the surfaces of stones which are subject to wear by water action are usually rough, and in the case of flints are covered with minute cracks and sometimes small cutting edges, it will be seen that this rubbing action may be somewhat akin to filing of metal with a file, and doubtless particles are thus removed from the surface.

In the case of timber which is exposed to similar action we have the constant blows breaking down the structure, and the obliquity of impact gives such blows a more powerful action in tearing away pieces of the timber, particularly so if the side grain of the timber is exposed. When the end grain is exposed it is not so easy to remove pieces, and the timber wears much longer.

Before leaving this aspect of the subject there is one other effect which must not be lost sight of. It was shown by the author in a paper read before the British Association in Dundee in the year 1912 that the effect of absorbed water on the strength of porous stones was very considerable. The strength of Portland stones which had absorbed only 4½ per cent. of water was reduced by about 40 per cent. in tension and 20 per cent. in compression.

Now it must be remembered that during the time when stones are being driven against a concrete face by the sea the face is kept practically saturated with water, and therefore the cohesion is probably reduced. It would seem to follow, if this is true, that if the face of concrete be made waterproof so as to prevent absorption of water it should reduce its rate of wear. However, the author does not attribute much importance to this as it is probable the waterproof surface would soon be worn away, exposing the concrete underneath.

### FACTORS GOVERNING RATE OF ATTRITION.

Concrete is composed of particles of aggregate held together by cement, and however good the cement may be it usually forms only a small proportion of the concrete. It is, therefore, on the aggregate we must rely chiefly for resisting wear.

It is, of course, assumed here that we are dealing only with the harder aggregates and not with such materials as breeze, broken brick and the like, which no engineer would use in concrete likely to be exposed to abrasion.

The qualities in an aggregate which help to resist wear may now be briefly considered.

*Size of particle.*—Since small particles of stone are more easily crushed than large, it is obvious that the larger the aggregate on the surface of concrete exposed to attrition the better, regarded solely from the present point of view. If a concrete surface exposed to sea action, on a foreshore where boulders are driven against the face, be examined, and if such concrete be made of brittle material such as flint shingle, the empty sockets where small pebbles were embedded in the surface will be found. Also very often the pebbles will be found filling their sockets, but split into small fragments; subsequent blows break up such fragments and they are easily washed away. The empty sockets have then sharp edges which rapidly wear away, the stresses being concentrated, as already pointed out, by such sharp edges, and thus the process goes on. Larger stones on the surface of the same concrete will also be found covered with small cracks, as already referred to, and wearing away gradually also, but obviously opposing greater resistance to wear than the smaller pebbles.

*Nature of Aggregate.*—The nature of the aggregate used for making concrete is perhaps the most important governing factor over which we have any control. Different stones have very different resistances to attrition. The quality of a stone which enables it to resist wear is not easy to define. It is not hardness alone, since toughness is probably of even more importance. A very hard stone, such as flint or quartz, will crack easily and come away in chips, whilst a softer and tougher stone will not suffer such deep injury from a blow. Tests made by Messrs. Lovegrove, Flett and Howe * by placing weighed batches of stones in revolving drums and weighing the stones, chips and dust after a certain number of revolutions, gave some very useful results; the percentage of chips and dust being taken as inversely proportional to the ability to resist attrition. All stones were broken to 2 in. gauge, the drums were revolved at 20 r.p.m. for 8,000 revs., and the results obtained are summarised in the following table:—

| Petrological Group. | Mean percentage lost by attrition. |
|---|---|
| Quartz—Diabases | 3·82 |
| Quartzites | 5·50 |
| Porphyries and Porphyrites | 6·70 |
| Hornfels | 7·50 |
| Granites, Diorite, Gabbro, Gneiss | 10·00 |
| Andesites | 10·00 |
| Flints | 10·00 |
| Diabases, Dolerites and Basalts | 12·73 |
| Limestones | 20·00 |

Although these figures represent average results, it is to be noted that the figures for any group of stones showed very great variation between the highest and lowest, and such a table gives only a general idea of the ability to resist attrition. The author has found "Elvan Granite" to be one of the best stones for resisting wear; while being extremely hard it also has great toughness.

*Nature of Concrete surface.*—The effect of projections in concentrating the force of blows has been already referred to; corners of piles, small projecting particles of aggregate and such like, all suffer more severely than would a flat face of concrete. This is a condition not to be entirely avoided as, however smooth a concrete surface is to begin with, owing to the fact that it is not homogeneous, but made up of harder and softer parts, it tends to wear rough by attrition. Harder pieces of aggregate project, while the softer cementing material is worn down; thus attrition tends to assist itself to some extent, and we have a vicious circle established. When the aggregate is tough and not liable to break easily under blows the surface remains smoother and better able to resist wear than when a brittle aggregate is used.

There is, however, another effect of irregularities which is quite apart from their action in concentrating the force of blows:—Very often the blows received by wall surfaces are not normal to the surface, but glancing, so that boulders are driven along the face. When this is so and a glancing stone is brought up by striking a projection of any sort there is a greatly aggravated rate of wear on the projecting part. This effect was very apparent in the case of the earlier type of reinforced concrete groyne erected.† It was found that where the groynes were exposed to the action of coarse shingle the projecting columns suffered very badly. Subsequent groynes in which the columns and slabs were made of the same thickness, giving a smooth face, resisted wear very well. The columns and slabs were made of Elvan granite concrete in the proportion of 1 : 2 : 4 ; the granite being broken to pass a ¾ in. mesh.

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* *Attrition Tests of Road-Making Stones.* St. Bride's Press, 1906.

† Owens and Wood on "Reinforced Concrete Sea Defences," *Min. Proc. Inst. C.E.*, Vol. CLXXXIX., 1911-12.

It is clear, therefore, that a smooth, unbroken surface is more satisfactory for resisting wear than one with projections or irregularities of any kind.

*Size of beach material.*—The larger the size of the stones composing the beach the greater the wear due to their action when driven forward by rough seas. Concrete structures on sandy shores suffer little or no attrition, but when exposed to the grinding of coarse shingle they wear rapidly away.

This will be easily understood when it is remembered that the force of the blow is directly as the weight of the stone striking, the velocities of impact being equal. Comparing the force of blows delivered to a surface by shingle of a diameter of ½ in., 1 in., 2 in. or 3 in., and taking the particles as being more or less spherical, which they usually are, we observe an interesting result :—

The volume of a sphere is equal to $\frac{4}{3}\pi r^3$ or $\pi d^3/6$ and as the weight is proportional to the volume, if we take the weight of the ½ in. pebbles as unity, we get the weights of the ½ in., 1 in., 2 in. and 3 in. stones as respectively equal to 1, 8, 64 and 216. The blow delivered being directly as the weight, assuming the same velocity, is therefore proportional to these figures ; it will thus be readily realised what a profound effect the size of the shingle has upon the wear of a concrete surface against which it is driven.

There are, however, two limiting sizes :—On the high side when the stones become too large to be moved by the waves, and on the low side when the size of grain is so small that the particle suspended in the striking water fails to reach the concrete face, or is so small that the blow does not stress the face beyond the elastic limit.

*Exposure.*—When concrete works are situated on the open coast the rate of attrition of the surface, other things being equal, will depend upon the degree of exposure to storms. For example, if the coast faces the direction from which come the heaviest storms, the structure situated there will naturally suffer more than on a part of the coast facing in some other direction. Again, the fetch or distance over which the wind can blow in a straight line over water before striking the shore governs the size of waves, and the size of the waves has a pronounced effect on the rate of erosion. It will be remembered that the energy of a blow varies with the square of the velocity of the striking object, hence the importance of exposure.

*Position of structure on the foreshore.*—Keeping in mind the fact that water alone does not wear away a concrete face, but that some hard particles such as shingle must be present to act as eroding agents, it is obvious that the part of the foreshore where such eroding agents are most numerous will be the part at which attrition will be most severe.

Now the sea has a method of sorting out the materials of a foreshore into two main grades, the fine and the coarse, which we may call sand and shingle ; and usually the shingle is found from mean sea level on the foreshore to above H.W.M., whereas the lower part of the foreshore near L.W.M. is usually composed of sand unless there is no loose material available. Hence, the zone between mean sea level and H.W.M. is the zone of attrition.

Speaking now of foreshores which are exposed to tidal action and over which the water moves rhythmically to and fro with the rise and fall of the tide. If we divide such a foreshore into three zones, No. 1 near L.W.M., No. 2 near mean sea level, and No. 3 near H.W.M., we find that the time during which these three zones are exposed to wave action varies very considerably. The upper and the lower zones are exposed to wave action for a longer period than the middle zone. Again, owing to the fact that the gradient of the foreshore is not uniform, but increases as it approaches H.W.M., it follows that there is deeper water for waves to travel through at about H.W. than at any other period of the tide.

### RATE OF ATTRITION.

The conditions governing the rate of attrition are extremely variable. It is not, therefore, to be expected that any general rate can be given for any particular concrete surface, but the following rates are obtained from experience on the coast of Sussex. The coast faces nearly south and the foreshore is covered with coarse flint shingle, varying in size from perhaps ½ in. up to 4 in. in diameter. Under such conditions concrete near H.W.M. made from flint shingle was found to wear away at the rate of about 4 in. to 6 in. in a year. Concrete made from Elvan granite blocks pre-cast and only set in the face work when well seasoned, wore away in some cases to the extent of 6 in. to 1 ft. in four years. In another case, on the same shore, where the experiment was made of facing a sea wall with flint boulders set carefully in the face close together, it was found that these boulders had been worn away in the course of about five years. The flints used in this case were about 4 in. diameter.

In giving these instances of attrition it must be clearly understood that no general rules can be deduced from them, as on the same foreshore, and exposed to what appear to be exactly the same conditions, different parts of the facework showed very different rates of attrition.

It is fairly obvious that when the conditions on the foreshore are favourable to attrition, then no precautions which we can adopt will prevent it. The utmost we can expect to do is to reduce the rate.

### METHODS OF REDUCING RATE OF ATTRITION.

This problem may be dealt with from three different standpoints: we may—(*a*) aim at increasing the resistance of the surface to attack; (*b*) try to reduce the severity of attack; (*c*) provide for renewing the face when worn, and before structural damage has resulted.

*Increasing the resistance of surface to attack.*—As already pointed out, probably the most important factor which we can control is the hardness and toughness of the aggregate used. As a rule it will, however, be found that when large quantities of aggregate have to be provided for in any particular locality, it is convenient to use for aggregate whatever material is available in that particular place or within a reasonable distance.

When the design of the work permits, it is as well to use as large particles as possible for the face-work. The large particles resist blows which would fracture and destroy smaller ones.

Again, we may face the concrete with a continuous face of stone blocks composed of some hard resistant material, such as granite, flint, basalt, and the like. Strictly speaking, the face is not then a concrete face, but a stone one, and for this reason does not come under our present purview.

One more important point to keep in mind is that all concrete exposed to sea action, where there is liability to attrition, should, if possible, be well seasoned before exposure. It is not, however, easy always to do this, and it is best, whenever possible, to use pre-cast concrete for forming the faces exposed to attrition. In the case of piles driven into the sea bed or foreshore, they would naturally be pre-cast, and in the case of walls the part exposed to attrition is best formed with a block-work surface; and further, the faces of such blocks should, when possible, be formed with large stones or boulders embedded in them.

*Reducing the severity of attack.*—In the case of concrete work upon the foreshore it is often possible to get protection for the face by groyning the immediate neighbourhood, and so promoting accretion on the bed of the sea or foreshore. Such accretion shallows the water and reduces the size of the waves before they can reach the structure.

Again, the dumping of fine shingle upon the foreshore in large quantities, where it is available, such as from dredging operations in the vicinity, has been found to be a very useful measure.

Another method which the author has been experimenting with recently, not with great success so far, has been to try and substitute for the hard incompressible face of the concrete a softer, more elastic face. The idea underlying this is to reduce the maximum intensity of the blows from boulders. The maximum stress being a function of the amount of the depression of the face before the boulder is brought to rest would obviously be reduced by increasing the compressibility of the surface. How to obtain such a surface is, however, the difficulty. The experiment has been tried of giving a coat of tar mixed with pitch and bitumen to parts of the surface of sea-walls exposed to attrition, but not with great success. A further development of this experiment is now being tried, in which a facing of wood blocks laid with the end grain exposed is being given to the surface of the wall. Such a face would have the further advantage of being easily renewable when worn.

*Renewing the face.*—As it is unlikely that any of these methods will produce complete immunity from attrition, the third method of dealing with the trouble—*i.e.*, by providing for renewing the face when worn, is probably the most efficient when it is applicable. It is not, however, always possible to do this, especially so in the case of piles and small concrete structures, but it is not so difficult when dealing with large expanses of surface such as provided by sea-walls. A method developed by the author for such, and used with success, is to build in front of the wall which has suffered severely from attrition, a thin secondary wall or face. This face is built up from a foundation of its own or from a ledge left on the original wall foundation for the purpose, and is about 2 ft. thick. It is found that such a face wall is not liable to be disturbed by the sea, and it can, of course, be easily renewed when worn. Such refacing walls have their surfaces formed by embedding large flints of about 4 in. diameter in the concrete behind the shuttering, and although when the shuttering is removed a smooth concrete face is shown, this soon wears away, exposing the flints, after which the rate of attrition is very much reduced.

In the case of piles which are exposed to the wearing action of shingle, it is very often the case that such wear is located within a comparatively short part of their length, and then it is possible to protect them by such means as surrounding the part at the level of the shingle or boulders causing the attrition, with concrete of such dimensions that the wear does not produce any structural damage for a long time.

## DISCUSSION.

**Mr. C. H. Colson, O.B.E., M.Inst.C.E.**: The subject of attrition generally was one of very great importance to all. To those in the Admiralty it was very important, because they had under their control quite a number of breakwaters, particularly at Portland, Plymouth, and Dover. These were very subject to attrition, and although they did not suffer from small shingle, they did suffer considerably from the very large lumps of rubble of which they were made. Continuous efforts had been made to get rid of this attrition, and the only way in which they had been at all successful had been by increasing the size of the rubble. They had dealt with the problem from almost the opposite point of view to that put forward by the author, in that they had tried to reduce the velocity of the fragments, not by in any way reducing the force against them, but by increasing their own size. Down at Plymouth, for instance, they had tried with blocks weighing 250 tons made *in situ*. Generally speaking, he had found there, as the author had advocated, that it was very important to have the concrete rubble or blocks well seasoned before they were put into position and allow them to be subjected to attrition. The practice at Plymouth now was to make the blocks of from 60 to 80 tons in the harbour and dump them on the face of the breakwater. These stood very well when they were put into position, whereas the 250-ton blocks which they used to make and put into place immediately suffered very severely from attrition at the Plymouth breakwater. At Portland the same thing applied, and there they had removed the trouble by paving the surface of the breakwater and making it smooth. They had been quite successful. He would rather like to hear what the author had to say as to the use of bitumen blocks for the face of a sea wall. Would it be possible to make thin facing blocks of hot bitumen and then build these into the face? At Dover the blocks used were from 40 to 60 tons in weight, and all those which were subject to attrition were faced with granite. These were small bits of granite about 18 by 9 by 9 in. built in as one face on the concrete block. That had been successful from the point of view of attrition from shingle as well as from ships. There was, however, trouble on the eastern corner from the shingle coming round.

**Mr. A. Honeyset** made mention of one point which was probably unknown to many of the members with regard to the curious cones which resulted from the fracture of the flints. Some years ago the late Mr. W. F. Stanley, the well-known instrument maker, conducted some experiments by firing leaden bullets into water, and he took care that the bullet entered the water always perpendicular to the surface, and the result was very peculiar. It fully bore out what had been said with regard to this conical fracture, because apparently a similar cone was formed under the water, and the point of the cone was violently driven into the leaden bullet, which was hollowed out and expanded and formed a conical trumpet mouth. This hollow became larger the further the bullet went on. The speaker also thought that the author was a little bit hard on the large pebbles. He fancied the effect of them was rather exaggerated, because he did not see that the increase of area was taken into account. The importance of taking the area into account had been mentioned, but the author had apparently forgotten that although the mass of the pebble increased as the cube of its linear dimension, its area increased as the square of its linear dimension, and, therefore, its destructive effect should be much less than the relative figures given in the paper. With regard to the use of bitumen for the facing of concrete, the author had said that he had tried it, but he believed he had tried it on a very small scale and probably with a very small thickness. Some experiments which he (the speaker) carried out some time ago in connection with another substance than concrete, in which the question of erosion and destruction by impact figured very largely, he found that the mass of the material experimented with had a very remarkable effect. He was quite astonished at the importance of mass. A very thin coating of the plastic material very soon wore out, but if it was increased in thickness beyond a certain limit its life seemed to be almost infinite. That was due, he believed, to the fact that it was necessary to get a certain mass which would absorb the work done. If it did not properly absorb the work done it went to pieces, not by attrition or grinding or wearing away, but simply by shattering under the strain of the internal stresses produced. This showed that if a plastic material was to be used on concrete it would have to be of considerable thickness, and he was going to suggest that possibly a way of doing this would be to face the concrete with a hard material such as flint stones bedded in a bituminous concrete or a concrete which had a certain amount of plasticity. He did not know whether it had been done, but he gathered that something similar had been done from what the previous speaker had said.

**Mr. Colson** said he had not used bituminous blocks. What he had in mind when he was speaking was paving blocks which had been used to a considerable extent for paving of roads, and on the one or two roads where he had seen them they had withstood severe traffic very well. That, of course, was a very different thing, and he would like to hear whether the author had used anything of the kind in his work.

### THE LECTURER'S REPLY.

**Dr. Owens**, replying to the discussion, said, with regard to the possible use of bitumen for facing, that he had been working along the principle of attempting to give a resilient face, but the method of doing that which had been adopted had not been very successful so far. What he had in mind with reference to bitumen was to prepare concrete blocks with a bitumen face. The exact details had not been settled, but what he contemplated was to prepare a bitumen face of about one inch in thickness with thin dove-tailed grooves or projections on the back to bond the face to the block, and then to put concrete on the top of it. There ought to be something in that method, although Mr. Colson's suggestion that there should be a bitumen brickwork face on the concrete blocks seemed to be a good plan also. With regard to the importance of mass, what Mr. Honeyset no doubt meant was the necessity for a certain thickness of coating. It was very obvious that if there was a certain energy in a boulder which struck the facing, as there necessarily was to be effective, the facing must absorb all the energy before it has penetrated. Therefore, the thickness of the facing must be such that any dent given by the boulder would not penetrate it, or nearly penetrate it, so that its thickness depended upon its resistance or its co-efficient of elasticity, if it might be so called. It came about in this way. The energy of the boulder must be absorbed by the resistance due to the facing multiplied into the distortion of the face, *i.e.*, the work done. Therefore, the thickness of the face must depend upon the material used, and if it was a strong material it might be thinner; at any rate, it was a function of the strength of the material. Mr. Honeyset had pointed out the curious effect noted by Mr. Stanley when firing bullets into water and the possibility of it being due to a cone formed in the water. That was a piece of new information to him. He did not know before that a bullet fired in that way would open out. He had often fired bullets into water, but had never got them to do that.

It had also been said that he had been hard on the large stones, not realising that as the stones increased in size the surface of contact was larger also. That, however, was not quite true, because what he had kept in his mind was this. Concrete did not give a perfectly smooth surface. There were always little projections to be struck. There might be a projecting piece of aggregate, say, ¼ in. diameter, and it did not matter whether it was a big stone or a little stone which struck that. The area of contact was about the same. It would probably break in any case. Similarly in dealing with the blows at corners. The effect of the area of the boulder striking was not very important, although it came into it to some extent. A big round boulder would have a larger area of contact, but sometimes it had a nasty lagged corner, and the size again backed it up. Another suggestion made was to set the stone facing in a bituminous cement. He thought that what would ultimately happen in that case would be that the stones would be broken up or they would wear away, and then the bituminous cement would have to be depended upon, and they would come back to the bituminous facing again. He rather thought that the bituminous facing, or a facing of a similar nature, was worth going into more fully.

**The President** asked what would be the result upon the life of a wall which was paved as suggested

**Dr. Owens** said the idea of paving was to pave the face of the walls with big boulders, but the life of the pavement was not very long. For instance, a pavement of flints of 4 to 6 in. in size would last under heavy attrition for four or five years. Everything depended upon the severity of the attrition, upon the exposure, and upon the size of the boulders which were hammering. Every case had to be taken on its own merits.

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

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## REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER I.

1. Concrete is strong in compression and weak in tension.

Average values when 4 weeks are 1,600 lb./in.$^2$ in compression, and 160 lb./in.$^2$ in tension, both breaking values, not safe values.

At the age of 3 months and over, average values are 2,400 lb./in.$^2$ and 240 lb./in.$^2$ respectively.

2. A plain concrete beam slung between two supports and loaded in the centre has its upper portion compressed and its lower portion extended. This is obvious by considering the curved shape it takes up, and remembering that the ends remain square to the central axis.

It will therefore fail when the bottom acquires a tension stress of 160 lb./in.$^2$ (assuming we adopt the lower figures), and as the top will then only be stressed to 160 lb./in.$^2$ also, the great compressive strength of the material is not brought into play, and the beam is therefore very heavy and wasteful.

3. We can make the beam much stronger by strengthening the bottom, by inserting in it steel bars which will supply the tensile strength in which the concrete is deficient, until the tension side is now strong enough to bring the full strength of the compression in the top into play.

Roughly, the beam will then be ten times as strong as before.

4. Up to this limit, the concrete is not fully stressed, beyond it any additional steel produces very little increased strength because the concrete strength is then the limiting consideration.

The point at which the steel in tension just balances the concrete in compression is therefore called the *economic percentage*. With usual values of stresses, its value is 0·675 per cent.

5. If the steel bars in tension are stressed up to the usual working stresses, the concrete will have cracked on the tension side of the beam.

This can easily be proved as follows :—

6. When steel is stressed in tension it elongates, and the amount of the elongation depends directly on the stress, on the length of the bar, and on the material. (This is called *Hooke's Law*.)

7. This is expressed by the formula :—

$$e = \frac{t \, . \, l}{E} \quad . \quad . \quad . \quad . \quad (1)$$

where

$e$ = elongation in inches.

$t$ = tensile stress in lbs. per sq. in.

$l$ = length of the bar.

$E$ = a constant depending on the material.

The constant $E$ is called the *coefficient of elasticity*, or *Young's modulus*, and is found by stretching a steel bar in a testing machine and measuring the amount a given length of bar elongates for a measured stress on the bar. In other words, we measure $e$, $t$, and $l$, and then find $E$ by substituting their values in equation (1).

8. $E$ is only a constant with ordinary mild steel up to a stress of about 32,000 lb. per sq. in. (therefore called the *elastic limit*). After this, it *yields* visibly, although before this the elongation was so small as to be invisible except with very delicate apparatus.

Up to the *yield point*, however, the coefficient $E$ is a constant; in other words, whatever values of stress and length we take, the corresponding value of the elongation will be found to be such as to always give the value to $E$.

This value is 30,000,000 lb. per sq. in. In other words, a bar 100 inches long, stressed to, say, 30,000 lb. per sq. in. will elongate

$$e=\frac{30{,}000\times 100}{30{,}000{,}000}$$

$$=\tfrac{1}{10}\text{ in.}$$

Alternatively, our formula enables us to say, from a measurement of the elongation, how great the stress must be producing it.

For example, if we are told a steel bar 100 in. long is elongated $\tfrac{1}{10}$ in. by a tensile stress, we can say at once that the stress must be

$$t=\frac{e.E}{l}=\frac{\tfrac{1}{10}\times 30{,}000{,}000}{100}$$

$$=30{,}000\text{ lb. per sq. in.}$$

And if the cross sectional area is 2 sq. in. the total tension on the bar must have been 60,000 lb. (since the *stress* is the load divided by the area).

9. Now a similar relationship exists with regard to concrete.

If a specimen of concrete is subjected to tension, it also elongates. The elongation is extremely small, but just measurable with delicate apparatus, and, as with steel, it is found that there exists the relationship between stress, length, and elongation expressed by the formula

$$e=\frac{t.l}{E} \quad . \quad . \quad . \quad . \quad (1)$$

$E$ is a constant as before, but only has a value of 2,000,000 in the case of concrete, one-fifteenth that of steel.

10. In other words, the elongation of concrete for a given stress is fifteen times as great as for steel, or, conversely if two bars, one concrete and one steel, are stressed so that they elongate the same amount, *the stress in the steel will be fifteen times as great as that in the concrete.* This is an extremely important result.

11. Now in a beam of concrete having steel bars in it, which is stretched or compressed, one of two things must happen.

Either (*a*) the steel elongates or shortens exactly the same amount as the concrete immediately surrounding it;

Or (*b*) the rods slip in the concrete.

12. Now, if slipping takes place, cracks occur, and it may be accepted at this stage that in good design such slipping is adequately guarded against, except in exceptional circumstances, by methods which we will describe later.

Hence, in general, alternative (*a*) applies, and the steel elongates or contracts the same as the concrete surrounding it.

Therefore, from par. 10, *the stress in the steel will be fifteen times as great as that in the concrete.*

13. It follows that if we stress the steel to 16,000 lb./in.$^2$ in tension, the concrete stress should be

$$\frac{16{,}000}{15}=1{,}066\text{ lb./in.}^2\text{ in tension.}$$

But, as explained in par. 1, concrete breaks in tension when it is stressed to somewhere below 240 lb. per sq. in.

Therefore, with the steel stressed to 16,000 lb. per sq. in., the concrete will definitely have cracked in tension, and is therefore incapable of resisting tensile stresses.

*Hence the steel must be designed to carry the whole tension, receiving no assistance from the concrete.*

14. Do not suppose that the cracks do not exist because they cannot be seen with the naked eye. They are generally so fine that they cannot be detected, as may be readily calculated as follows.

The elongation of the steel in 12 inches, if stressed to 16,000 lb. per sq. in., is

$$e=\frac{12\times 16{,}000}{30{,}000{,}000}$$

$$=\cdot 0064\text{ inches.}$$

About $\tfrac{1}{160}$ of an inch.

So that if the cracks are 12 in. apart this would be their thickness, and if nearer together, proportionately less.

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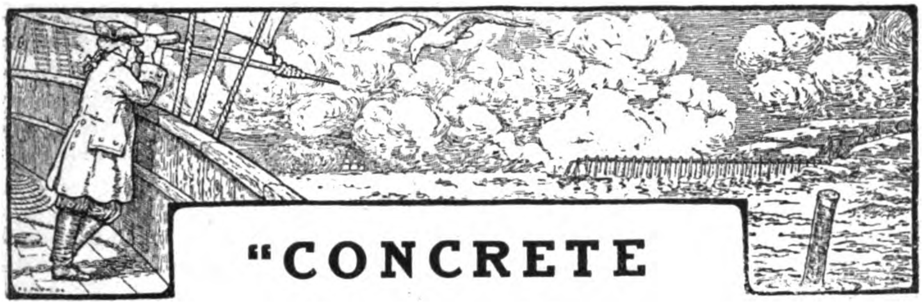
*The Department of Scientific and Industrial Research* has removed its offices to 16–18, Old Queen Street, Westminster, S.W.1. Telephone: Victoria 7940.



# "CONCRETE SHIPBUILDING"

## REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

## CHAPTER X.

### CLASSIFICATION AND SPECIFICATIONS.

Before the insurance companies will accept the risk of loss or damage attending any vessel it must conform to their regulations. Consequently, these form the chief feature of any specification for craft of all kinds.

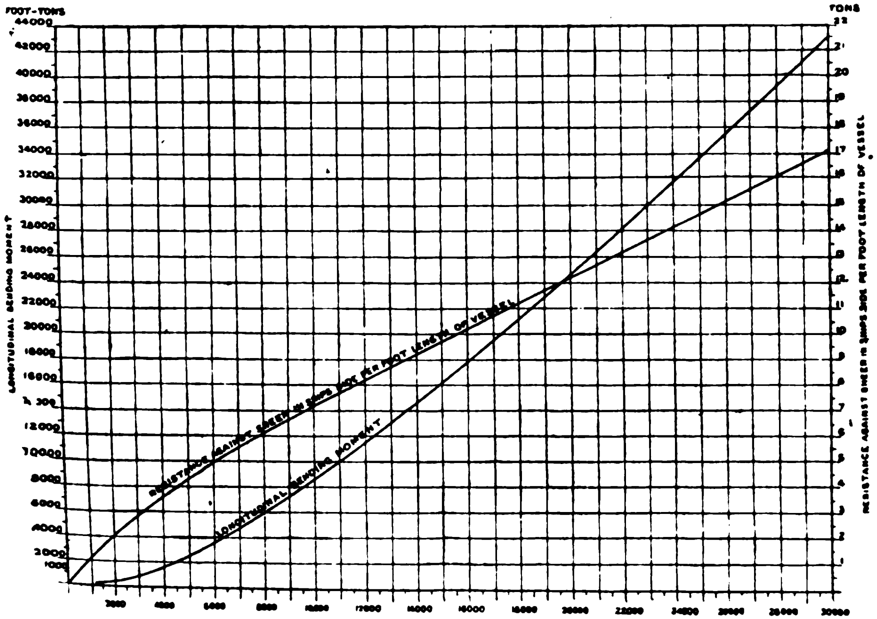


Fig. 168.

The Bureau Veritas of Norway has published the following regulations :—

The stress on the steel is not to exceed 6·35 tons per sq. in. when in compression and 5·08 tons per sq. in. when in tension.

The modulus of elasticity of the concrete is to be taken as one-fifteenth of steel. The stress when in compression is not to exceed 570 lb. per sq. in., or one-sixth the strength of the concrete. The stress when in tension must not exceed 57 lb. per sq. in.

The maximum bending moment and shearing force for a vessel is assumed in relation to the longitudinal number of the vessel, and are sent out by curves (*Fig.* 168). The assumed moment appears to be nearly 50 per cent. more than the actual moments found by calculations.

The bending moments for floors, frames and beams are assumed (see *Figs.* 169, 170). These are related to the transverse number in the case of the floors, the transverse number multiplied by the height for the frames, and the length in the case of the beams.

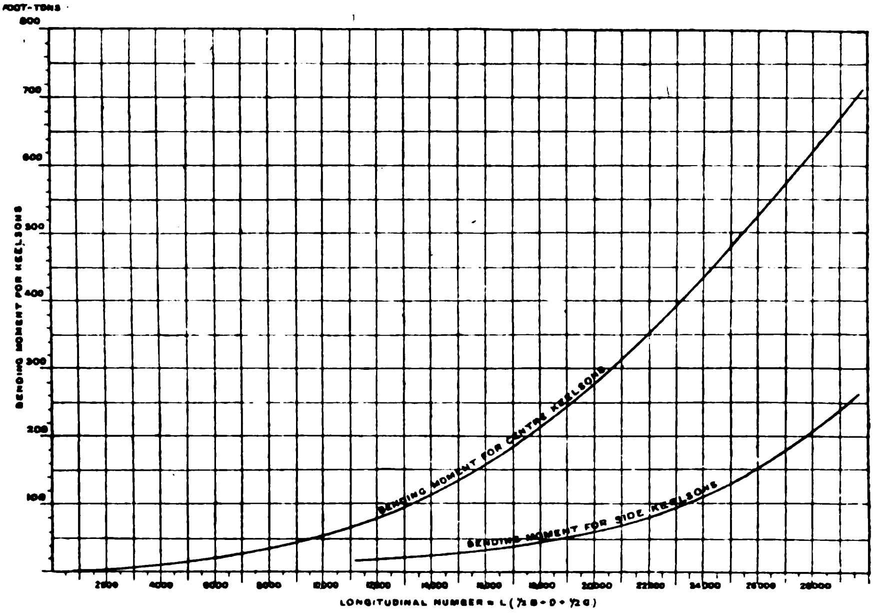


FIG. 169.

The bending moment for the centre keelson is given in the curve (*Fig.* 169) and is related to the longitudinal number. When the vessel is more than 27 ft. beam, side keelsons, one on each side, should be fitted.

The outer bottom, between the floors, is to resist a water pressure equal to 50 per cent. more than the maximum draught, and in foreign-going vessels for 20 per cent. amidships (25 per cent. of motors fitted aft), to resist a pressure of twice the vessel's maximum draught. The inner bottom where fitted, must resist a pressure equal to 25 per cent. more than the maximum draught. The sides of the vessel between the frames should resist a pressure of 75 per cent. of the maximum draught, the forecastle 60 per cent., and the bridge or deck-house 50 per cent. The deck between the beams must resist a pressure equal to 35 per cent. of the maximum draught.

Stanchions to beams and hatch ends are supposed to bear a weight of water of 4·35 ft. on the main deck, and 2·85 ft. on the upper deck.

A watertight bulkhead must resist a head of water equal to its height, plus 3·35 ft.

The deck and bulkhead steel rods must be covered with at least ⅜ in. of concrete, and those in the bilges with at least ¾ in. of concrete.

Where rods have to resist pressure, they are to be spaced not more than 15 diameters apart.

The overlap of rods is to be 60 times the diameter.

Welding is only allowed by special permission.

A solid fender of wood is to be fitted for the whole length of the vessel above the load line.

Ceiling and cargo battens must be fitted in all cases.

When the hatch coamings are made of concrete, they must be boarded with wood or protected in some other way against knocks.

The stern frame is to be of the size required for a steel vessel of similar size.

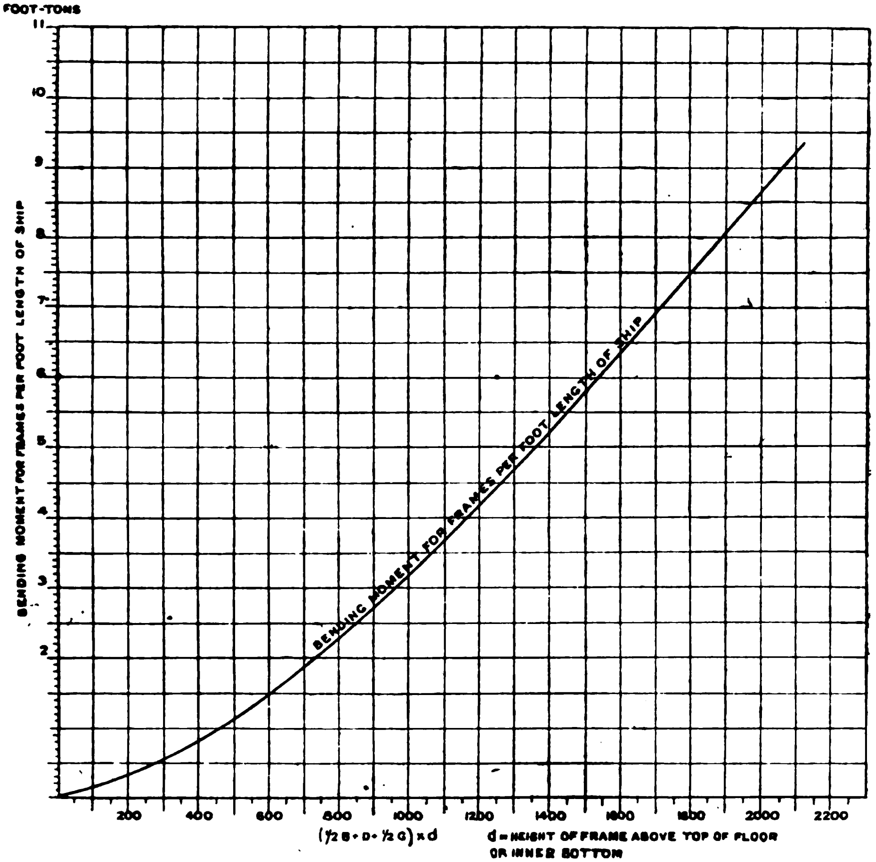


Fig. 170.

The Marine Department of the Board of Trade issued preliminary instructions with regard to sea-going reinforced concrete ships, which must comply with the requirements of the Merchant Shipping Acts, and must be built under the inspection of the surveyors of either Lloyd's Register, the British Corporation, the Bureau Veritas or the Board of Trade. Applications for the assignment of loadings should be accompanied by detailed calculations of the strength of the vessel, drawings showing the construction of the vessel and the arrangement of the reinforcement, and a general specification of the materials and the method of construction. The load-line disc and the marks in connection therewith are to be permanently marked on a steel plate 33 in. by 18 in. by ¼ in., embedded in the concrete flush with the outside, and suitably secured.

The American Joint Committee has suggested that specifications for a concrete vessel should embody the following principles :—

1. Both cement and aggregates should be selected with great care, to ensure a concrete of maximum efficiency.

2. The concrete should be placed in one continuous operation, to ensure monolithic construction. The concrete mixture should be such as will develop a crushing strength in excess of 3,000 lb. per sq. in., when tested in standard cylinders at twenty-eight days. A concrete consisting of one part Portland cement, one part sand and two parts ½-in. aggregate may be expected to give such a concrete. The mixture and workmanship in placing must be such as will assure impermeability.

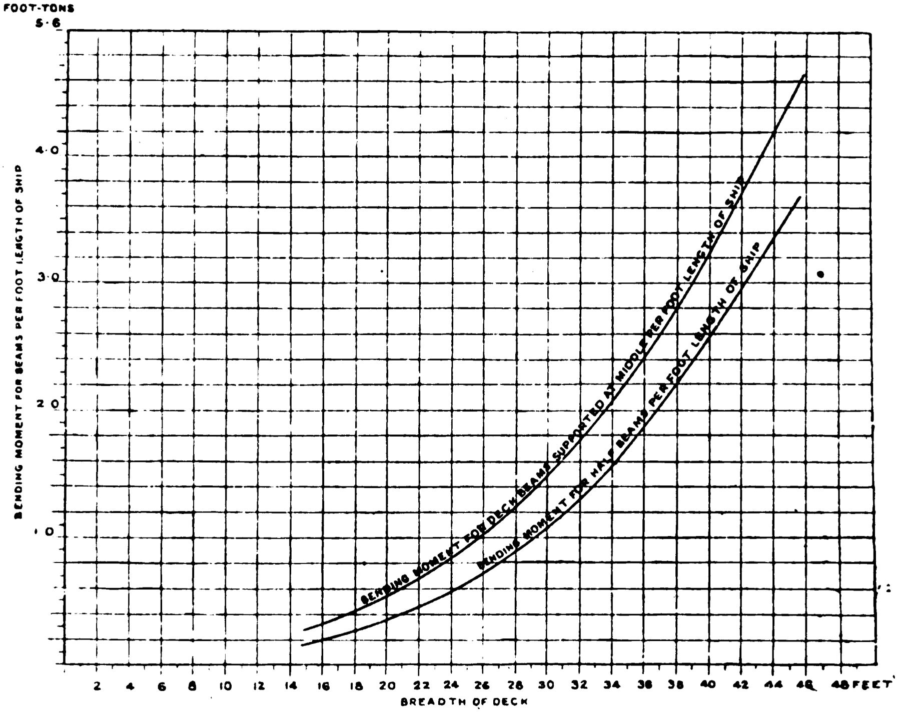


Fig. 171.

3. The reinforcing steel should be in the form of deformed bars and should be galvanised.

4. In parts of the vessel where cracks in the concrete would tend to cause leaks, the stress in the steel should be kept low (preferably less than 12,000 lb.).

5. Some form of elastic waterproofing coating should be applied to the hull below the deck.

# NEW BOOKS
## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

### SYMBOLS.

**Mnemonic Notation for Engineering Formulæ: Report of the Science Committee of the Concrete Institute; With explanatory notes by E. Fiander Etchells, Assoc.M. Inst.C.E., A.M.I.Mech.E., Hon. A.R.I.B.A. etc.**

London: Published by the Concrete Institute, Denison House, Vauxhall Bridge Road, S.W.1. 8vo. Price 6/3 post free.

The supreme importance of symbolism is not generally recognised because, availing ourselves of it every day of our lives, we forget to think of the place it fills. The very word when it is used conjures up visions of a limited application, to most persons probably the idea of religious symbolism. When we come to think of the matter in the widest sense of the word we begin to appreciate that the history of civilization is merely a record of the advance of symbolism. The distinction between brute creatures and humans is the ability of the latter to convey ideas and consecutive thought by means of language. Words are, indeed, but symbols. As soon as language goes beyond the elementary structure of savage tribes, the number of words increases and the arrangement becomes methodical, so as to permit of ordered discourse incidental to reasoning. The richer the civilization, the finer the culture, the greater in number of words, and the more elaborate becomes the language in order to permit us to convey the finer shades of meaning. As soon as we proceed to logical argument—and especially that particular form of logic called mathematics—we find the need of abstract symbols, and in order that the expression of our thought can proceed with ease we have to use an abbreviated symbolism as a shorthand. The great advances in mathematics, pure and applied, have proceeded from, or gone hand in hand with, improvements in the shorthand symbolism. Great thinkers have always paid much attention to the symbols they employ, in order not only to assist their own thoughts but to convey their ideas and their discoveries clearly to others. We need only to remember the strides forward that occurred through the invention of an improved notation by the eminent scientific thinkers of the past such as Euclid, Archimedes, Newton, Leibnitz, Descartes, and Kelvin, to appreciate the importance of the subject. Every intellectual man has, as a student, to gather his knowledge from past thought and discovery, and mere clear thinking and economy of time and labour require the most careful attention to the notation in which past thought and discovery are expressed. We see then the desirability of having a good abbreviated symbolism as a shorthand and a mnemonic aid. Pure science is now international, and the advantages—even the necessity—of a standard notation have become so apparent that we already possess a very good system for such subjects as mathematics, physics, chemistry and electricity, which we need only consider for a moment to understand how hampered we should be without the standardised shorthand we employ to record facts and express ideas in those subjects. When we consider applied sciences we find, by comparison, how backward we are for lack of a simple standardised notation. Take biology, zoology, botany, surgery, medicine, engineering as examples. The confusion due to different workers expressing the same facts and ideas in different languages and in various ways wastes time and makes study tedious, apart from the difficulty caused to ordered thought and the record of data in a simple form to which easy reference can be made later. These applied sciences must, in turn, affect pure sciences, because progress in the latter springs fundamentally from the necessities of the former in their advance.

Engineering forms so important an element in modern civilization that the first real attempt at standardisation and simplication of notation is fittingly being made with it. The Concrete Institute and the Institution of Electrical Engineers, as two of our younger institutions, have also fittingly been the pioneers. Engineering is mostly a branch of applied mathematics and records its data in mathematically expressed formulæ.

Pure mathematics have largely found inspiration from engineering applications, and consequently we find upon investigation that the symbolic notation of pure mathematics is open to improvement, because it still contains symbols invented by past thinkers which do not always work well in combination. Mathematical notation can be improved upon, and it is extremely important that it should be. As proof of this we need only remember the way in which Newton's notation for the infinitesimal calculus hampered the progress of our mathematicians using it as compared with the assistance the Leibnitz notation gave to the continental mathematicians. In this book a number of most useful proposals for improvement in ordinary mathematical notation are made, such as which of two or more ways of expressing the same thing is preferable, and how slight practical improvements can be made in writing or printing symbols, all of which are acceptable and will be adopted because they do not make any violent break with tradition and appeal to us by reason of their common sense, which merely means that they are obviously useful.

The work under review consists of the Report of the Committee proper, followed by an appendix by Mr. Etchells, who is the prime mover in this matter and deserves every praise for his efforts. We surmise that the true relation of the Committee and Mr. Etchells has been that they have served as the patient upon which Mr. Etchells could experiment. He is responsible for the formulation of principles and co-ordination and uses the Committee to decide what are truly practical symbols commendable to the rank and file for general adoption because of their easy assimilation in view of what has been used before, ease of memorisation and ease of writing and printing. The Committee has served as a very keen critic. That is a very good way of getting a rational system illustrated by truly practical examples of the application of definite principles.

The appendix by Mr. Etchells forms very interesting reading, and we recommend all students of mathematics and engineering to read it. We hope that Mr. Etchells will write more fully later on the wider applications of mathematical symbolism and that he may find the time and opportunity to improve the notation of physics, mechanics, and mechanical engineering as he has done for structural engineering and reinforced concrete; the procedure which has led to such good results in this case might well be tried in the other cases, i.e., to have committees of representative institutions assisted by Mr. Etchells to formulate symbols. Mr. Etchells would be sufficient in himself to co-ordinate their work and prevent one lot of symbols conflicting with another

**"Structural Steelwork." By E. G. Beck.**
Longmans, Green and Co. 21s. net.

The author sets out to deal with the problem of constructional steelwork from the designer's point of view. He claims "(1) To present section modulus, moment of inertia and radius of gyration in a form which, though not less logical than that usually employed in text-books, will permit them to be visualised by any ordinary student; (2) the treatment for excentrically-loaded stanchions; (3) the method proposed for the analysis of framed trusses, using the line diagram of the truss as a stress diagram, and (4) the treatment of knee-ties and knee-braces."

On the whole, the author has well acquitted himself of his task, and is to be thoroughly congratulated on a practical work in which theory is used as servant rather than as a medium for showing that he knows more than the other fellow. The reviewer notices with pleasure that the author holds many views on details with which he is in complete agreement, though often neglected in practice with grave attendant risks.

We do not agree with the remarks in article 50 (p. 145), in which Mr. Beck maintains that the load of a beam cleated to the web of a stanchion appears to be excentric, but is not so, his reason being that the stanchion cannot "take there a slope greater than that taken by the end of the girder itself, and this will be extremely small in all cases."

This is true, but, unfortunately, a very small slope corresponds to big bending moments and stresses—we know, for example, that the steel beam, in spite of its "extremely small" slope, is actually stressed to about 7½ tons per sq. in., which is obviously not negligible.

The correct treatment here, when the joint is stiff, is obviously to calculate the actual slope and the moment and stresses produced by it, in regard to which the reviewer would be pleased to show Mr. Beck the results of analysis.

The book is to be thoroughly recommended.

# THE FOREIGN PRESS.

*The following are abstracts taken from the foreign Press relating to concrete construction.—ED.*

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**The Effect of Coal on Concrete.**—It is quite a mistake to regard coal as an inert material, as when stored in large quantities it undergoes oxidation and other changes which may easily result in spontaneous combustion, and this may cause serious damage to the structure in which the coal is stored.

The precise conditions under which spontaneous combustion occurs are not fully known, but the oxidation of pyrites (sulphide of iron) in the coal appears to be one of the chief causes. Some amount of moisture also appears to be necessary. The sulphide is partially oxidised to sulphate, but free sulphurous acid is also produced, and this may attack the concrete, even though no actual fire is produced. The heat generated by the combination of the acid and the free lime in the concrete assists the general development of heat in the coal, and may thus facilitate the production of a fire.

The density and low thermal conductivity of concrete prevent the escape of any heat formed by the oxidation of the impurities in the coal, and thus add to the risk of spontaneous combustion. In addition to this, concrete does not resist heat and pressure, so that it is liable to crack if spontaneous combustion occurs in the coal. Cracks in the structure are particularly likely to occur if the concrete is made of dolomite, as magnesium salts are readily soluble in the sulphuric acid produced by the oxidation of the pyrites; and as these salts dry they fall to powder, leaving a considerably weaker concrete.

The most difficult kinds of coal to store in large quantities are the light brown coals and lignites, as they are much moister than the harder coals and develop acidity and spontaneous ignition more rapidly. These and all coals which show portions of brassy material should only be stored in high concrete bins when the lower portion of the coal is in large pieces, with ample air-space between each, or when provision can be made for keeping the lower part of the coal quite cool. Where these precautions are not practicable, the inner surface of the concrete should be coated with carbolineum or other material which will prevent the coal and the products of its decomposition from coming into direct contact with it.

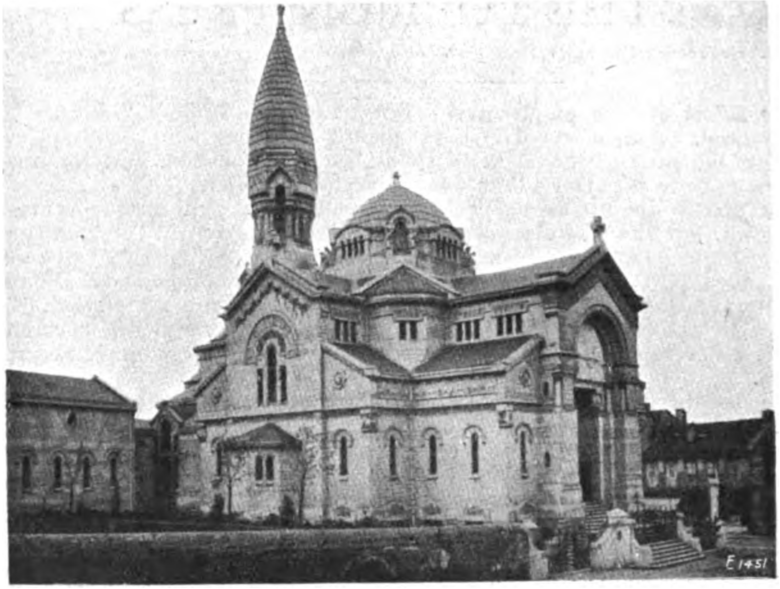
No precaution will avail if the concrete has been badly made or if it is too porous. For this reason, structures to be used for coal storage should always be built of tamped concrete and the inner surface should be well grouted so as to give it a dense, smooth finish.—*Beton und Eisen.*

**The Effect of Salt Water on Brickwork.**—The destructive action of salt water on mortar is well known, but the recent collapse of a brickwork building in Turin presents several features of interest.

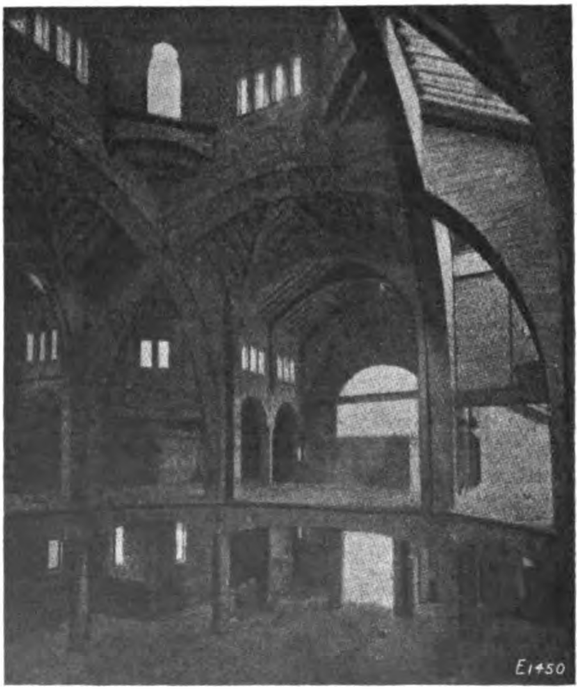
One of the arches in a factory engaged for more than forty years in salting anchovies and other fish recently collapsed, and it was proved that this was due to the infiltration of the brine into the brickwork. Both mortar and bricks had been so softened as to be quite useless. The total sodium chloride present was 8·36 per cent. on the dry materials.

This phenomenon shows that the action is wholly chemical, and not due to disintegration of the mortar by mechanical means, as is usually thought to be the case.—*Le Ciment.*

**The Reconstruction of Churches in the Devastated Areas.**—There is, in some quarters, an undesirable and even unreasonable prejudice against the use of reinforced concrete in church architecture, but to do this is to overlook such a well-known structure as St. Sophia, at Constantinople, and a number of lesser-known ones. Moreover, reinforced concrete can satisfy many architectural requirements which cannot be fulfilled in stone except at enormous cost, and in addition, concrete can be used to produce Gothic and other effects to an extent hitherto scarcely dreamed of in recent years. It works in well with other materials, and is, for this reason, an admirable material for repairing the ruined churches in the devastated areas of Belgium and France, as well as for enabling architects to give freer play to their ideas and imaginations in constructing new churches to replace those which have been so completely demolished as to be beyond repair.



Exterior View.
CHURCH AT ST. ETIENNE.



Interior View.
CHURCH AT ST. ETIENNE.
*Reproduced from "Le Béton Armé."*

By constructing church roofs of very tall Gothic arches, there is not only a saving in steel, when concrete is used, but a feeling of height and grandeur is obtained which is peculiarly fitting for church architecture, " wherein the soul should be tuned alike for prayer and praise." The use of concrete also enables the architect to depart from the customary single floor, with its many decorative drawbacks, and enables a structural arrangement to be used which is scarcely possible with other materials without great loss of free space.

Furthermore, a church built of reinforced concrete may make use of any local materials, and so be built in any desired style, so that it may reproduce in architectural form the characteristics of the locality and thus possess a distinction and character which is peculiarly its own.

The accompanying illustrations of the church at Sainte Etienne, which was built nine years ago, to the designs of P. Naulin-Lespès, show how concrete lends itself to great richness of effect both as regards spaciousness of the interior, massiveness and delicacy of the exterior and, with the aid of marble and other decorative stones, on which no stress is placed, any desired degree of sumptuousness may be obtained, just as no one looking at the magnificent cathedral of St. Mark at Venice would realise that its strength is due to a brickwork core, the beautiful marbles and intaglios being purely ornamental in character.—*Le Béton Armé.*

**Concrete Caissons.**—Edward Swoboda of Vienna has pointed out in a recent issue of *Beton u. Eisen* that as a concrete caisson weighs about six times as much as an iron one of the sama size, the latter is usually preferred, as it is so much easier to manipulate, does not require such powerful cranes, and can be lowered more accurately into position, He suggests that, by a more extensive use of wood in the construction of concrete caissons, this objection may, to an appreciable extent, be avoided.

As a caisson—as such—is only in use for an extremely short time and when it is sunk it merely forms the shell of a mass of solid concrete, it is important to build as cheaply as possible, and specifications intended for durable concrete structures are unsuitable for caissons. If due care is given to this matter, a considerable reduction in the weight and difficulty of lowering concrete caissons may be effected.—*Beton u. Eisen.*

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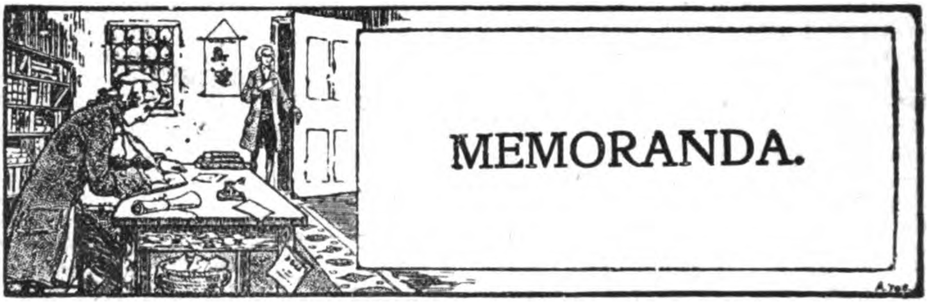
## MEMORANDUM.

**Unnecessary Complication in Design of Reinforced Concrete Structures.**—In his inaugural address as president of the Society of Engineers, delivered at a meeting of that body, Mr. Burnard Geen, Assoc.M.Inst.C.E., remarked that one of the problems facing the engineer of the future would be to practise rigid economy in the use of all materials of every kind which in the past it had been his function to employ. This would necessitate change of ideas in connection with the design of structures. The most pressing needs probably for many years to come would be supplies of iron, steel and coal. For this reason it might be anticipated that the employment of reinforced concrete would very largely supersede the employment of steel constructional work, owing to the fact that the former would permit the use of far smaller quantities of steel and the employment of larger quantities of material of which abundant supplies existed, or could easily be obtained. On the other hand, it must be remembered that there would be of necessity for some time to come a great shortage of timber, and it would therefore be necessary to conserve this most carefully. The development of a comprehensive system of unit construction might therefore be anticipated. In a great deal of modern design unnecessary complication was introduced. This was open to grave objection under the most favourable circumstances, and would require greater attention in the future. The objection to it in steel construction was bad enough, but in reinforced concrete construction it was a very serious one. Other things being equal, the design considered best by competent judges should be the one most simple, most direct, most readily inspected and fixed, judged on the same standard of efficiency.



# MEMORANDA.

*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**The Building Trade Exhibition.**—The attention of our readers is called to the International Building Trade Exhibition, 1920, which is to be held at Olympia from April 10th to 24th. This is the first time the exhibition has been held since 1914, and many new methods of construction introduced into the building industry will be shown.

**Concrete in the Chemical Industry.**—According to a paper by E. S. Andrews in the *Chemical Age*, reinforced concrete is suitable for many forms of structure used in the chemical industries, including the general buildings, water towers, cooling towers, storage bins and bunkers, tanks, vats, etc., though concrete made of gravel or Thames ballast is unsuitable for structures where the risk of a severe fire has to be considered. Broken bricks and stones are superior aggregates for such a purpose. In addition to the use of a suitable concrete, the design, dimensions and position of the steel reinforcement are very important.

Concrete tanks are specially suitable for use with chemicals because of their durability, resistance to acids of moderate strength, and the small amount of leakage around the outlets. These and other connections should be of brass or bronze and sufficiently stout not to require renewal, as a good joint cannot be made between old and new concrete in a thin wall. Concrete tanks may safely be used for storing Menhaden oil, lard, oil, fuel oils, and tanning liquor, a 4 per cent. solution of caustic soda, the chlorine solutions used in paper mills, but not for sulphite liquor and cider vinegar, unless the interior of the tanks has been treated with paraffin wax. Concrete tanks are coated internally with spar varnish to be suitable for storing kerosene and gasoline. Hot cocoanut oil and lard oil attack concrete, so that it cannot be used for storing these oils.

**Difficulties of Transport and Materials.**—At the Housing Conference which was held at Olympia last month, by the Royal Institute of British Architects, Mr. G. J. Drower, in dealing with the difficulties of transport and materials, said that if cement were to be used in the way in which it had begun to be used, the quantity required would reach 1,450,000 tons for 200,000 brick-built houses. The average yearly production for 1911-12-13 was about 3,000,000 tons, and of this we exported 716,000 tons. At present we were producing cement at the rate of 2,200,000 tons per annum, and this was increasing. . . . If concrete construction were adopted for all the 200,000 houses the total quantity of cement required would be nearly 3,000,000 tons.

**Concrete Castings for Machinery.**—A writer in the *General Electric Review* suggests yet another use for reinforced concrete, namely, to take the place of the huge metal castings, often weighing several tons, which are required to support the bearings of electrical generators. With the present knowledge of the proportions of cement, aggregate and water required to produce a concrete structure of large size with uniform strength in all parts, the manufacture of such castings should not present any problems which cannot readily be solved by careful design and construction. In addition to the great saving in cost which would result from the substitution of concrete for steel, the delays experienced at present in procuring such parts from the manufacturers would be eliminated, as the castings could be manufactured on the site. The freightage and shipping of the enormous castings used in modern plant often presents great difficulties, which would also disappear with the use of concrete. The General Electric Co. of America have manufactured some of the largest electrical plant in the world, and the writer referred to recommends concrete especially for stator frames and thrust bearings in hydro-electric installations.

**Concrete Cast in Paper Moulds.**—The U. S. Bureau of Standards is now using collapsible paper cylinders in which concrete test pieces are cast. These moulds are collapsible, and may be nested for transportation purposes, and can very easily be assembled when they are to be used. The moulds measure 6 by 12 in. and weigh only 7 oz. each, as against 22 lb. for the ordinary steel moulds. They consist of two-ply cardboard cylinders split lengthwise, which may be joined to form a cylindrical mould by means of a stapling machine. When the moulds are used they are left on the test-piece to serve as a protection during shipment.

**The Employment of New Materials.**—In the course of a lecture given at the R.I.B.A. conference last month at Olympia, Mr. W. A. Harvey, R.I.B.A., referring to concrete construction, said:—With regard to methods of construction, concrete had made the most progress during recent years. Both reinforced slabs and hollow blocks had been satisfactory for house construction, but the cost, even where aggregate had been readily available, was not appreciably less than bricks. Concrete could not be ruled out any more than other methods could be ruled out, for the enormous shortage of houses would necessitate the use of many useful materials. Experience had proved that solid-block hollow-wall construction was the most satisfactory form of concrete construction. In the case of hollow blocks it was possible to construct them in two layers of concrete of different aggregate, the outside impervious, and the inside of coke-breeze. If this precaution was not taken, the inside surface was unable to absorb the moisture condensed from the atmosphere, and the result was disastrous. The construction of steel-frame and concrete houses was very simple, and the method deserved special attention.

**Cement Concrete Building Blocks.**—In our last issue we gave the specification approved by the Standardisation and Construction Committee of the Ministry of Health. To this specification the following should be added:—

*Sizes*:—Plain blocks of clinker concrete shall not be less than 2 in. thick for buildings of one storey and 2½ in. thick for buildings of two storeys, except in the latter case where they have approved stiffeners and webs, they may be reduced to 2 in. in thickness.

*External Walls*:—or with an approved cavity block of the full thickness of the wall.

## HOUSING NOTES.

**Aberdare.**—The two tenders of Concrete Buildings, Ltd., have been accepted in respect of the following housing schemes: Abernant, 16 houses (parlour type) and layout complete, £12,494 9s. 4d.; and Cwmneol, 72 houses (parlour type) and layout complete, £63,000.

**Falmouth Scheme Started.**—Early last month the first sod was cut in connection with the Falmouth Corporation's housing scheme, and work is now in progress. The first forty-four houses are being built of concrete on the "Calway" system, at a cost of about £700 per cottage.

**Hammersmith.**—The Hammersmith Borough Council has accepted the tender of the National Improved Housing Co., Ltd., to erect 300 houses on the "Condual" system of concrete construction at a price of £214,653. The work is being done under the supervision of Mr. H. T. Hare, F.R.I.B.A.

**Hendon.**—The Hendon Council has accepted the tender of the National Improved Housing Co. for the erection of 244 houses on the Brent Hill site (near the Welsh Harp). The tender, for concrete construction, amounted to £189,996, the average cost of three types of houses ranging from £695 to £771. Each house will have at least three bed-rooms and a bathroom. The saving, as against brick construction, is about £26,000.

**Leeds.**—Three concrete bungalows have recently been completed in Nursery Lane, Moortown, Leeds. The accommodation of these dwellings is as follows: two sitting-rooms, four bedrooms, bathroom, kitchen, scullery, and usual offices. The construction consists of an outer wall of concrete slabs made of waterproof cement and an inner wall of the same material, leaving a cavity between the two walls. The slabs themselves are so constructed as to absorb moisture in the same manner as bricks, and the walls are strengthened by steel rods.

It is estimated that the smaller bungalow has been erected at a cost of £700 to £800, and the two larger ones at a little over £1,000, exclusive of the cost of the land. The plans were drawn up by Mr. C. Castelow, the architect.

The building operations have been carried out by Messrs. Wm. Thompson & Sons, Leeds, and the concrete system employed was that of the Whitehall Concrete Co., of Leeds.

**Manchester.**—It is intended to build 260 concrete houses on the Catterick Hall Estate, Didsbury at an average cost of £975 per house.

**Montrose.**—The Montrose Town Council have made application to the Board of Health for permission to proceed with the experimental erection of some concrete houses.

**Wandsworth.**—The Wandsworth Council are considering the erection of 250 concrete houses.

**Worthing.**—The corporation have under consideration the erection of 64 cottages, some of which are to be built of concrete blocks.

## PROPOSED NEW WORKS AND WORKS IN PROGRESS.

**Tilbury.**—Foundations. The U.D.C. propose constructing concrete and reinforced concrete rafts for 1,520 cottages.

**Manchester.**—A reinforced concrete water storage tank at the colony for epileptics, Langho, near Blackburn.

**Large Power House of Reinforced Concrete.**—A large power house is being erected in reinforced concrete by Messrs. Peter Lind Co. for the Powell-Duffryn Co. at Bargoed. This power house, which will have an output of 20,000 kw., is intended to extend the supply of electrical energy to the collieries of Messrs. Powell-Duffryn, and for generating power for the new pits at Deri.

**Concrete Picture House.**—Wilmslow Council have passed the plans for work on a picture house, on conditions that the walls, with the exception of the front, should be constructed of reinforced concrete. The use of this material, it was pointed out, would not interfere with the council's housing plans.

## ROAD NOTES.

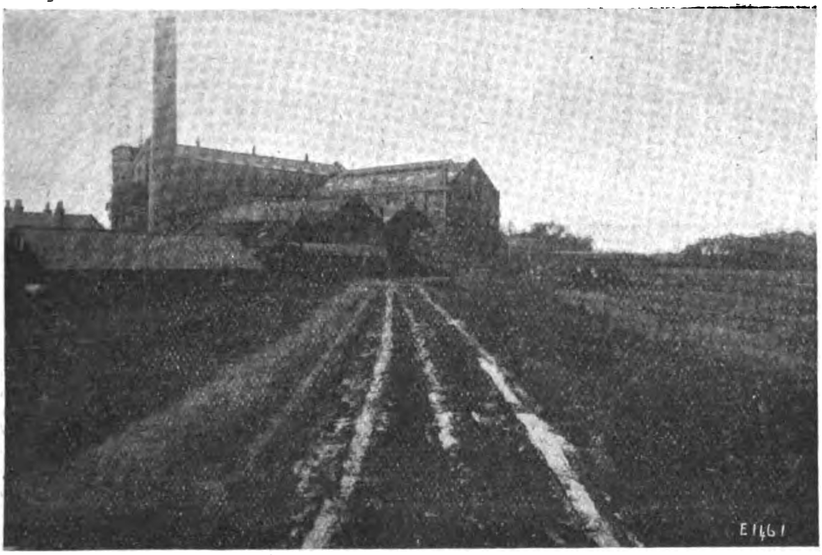
**Road Making.**—An interesting example of the possibilities of the cinematograph as an instructor in the field of engineering was demonstrated last month when, by the courtesy of the Allied Machinery Company, of 132, Queen Victoria Street, E.C., we had the opportunity of witnessing a series of pictures showing the latest American practice in road making of every description by the employment of machinery.

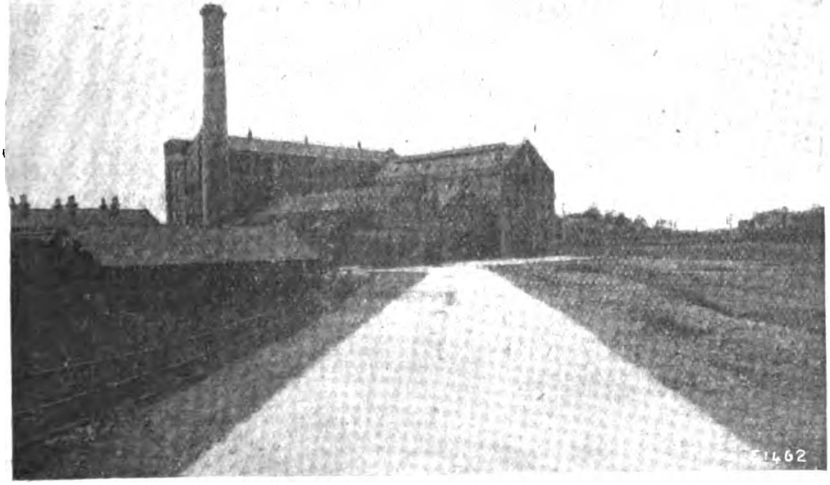
One of the films gave a fascinating presentation of the making of a length of concrete road from start to finish. It was shown how, by the skilful organisation of labour and the use of mechanical contrivances, a 700-ft. length of concrete road could be laid in a day by ten or twelve men, and it was of special interest to observe how the various processes, from the preparation of the sub-grade to the finishing off of the surface, followed one upon the other practically without a break.

Of course, the methods employed were those most applicable to American conditions, but the Allied Machinery Company are studying conditions prevailing in this country in order to adapt their appliances for use in England.

**Aberdeen.**—The district surveyor of the Deer District Committeee of the Aberdeenshire County Council, Mr. George S. Barry, in a report on his visit to the Road Congress in London, said he was much interested in the papers and the discussions, as he was convinced that with the increasing weight and quantity of traffic, the committee will have to face in the not distant future the question of adopting reinforced concrete as a construction for roads passing over a weak, mossy subsoil such as they had in abundance in the district.

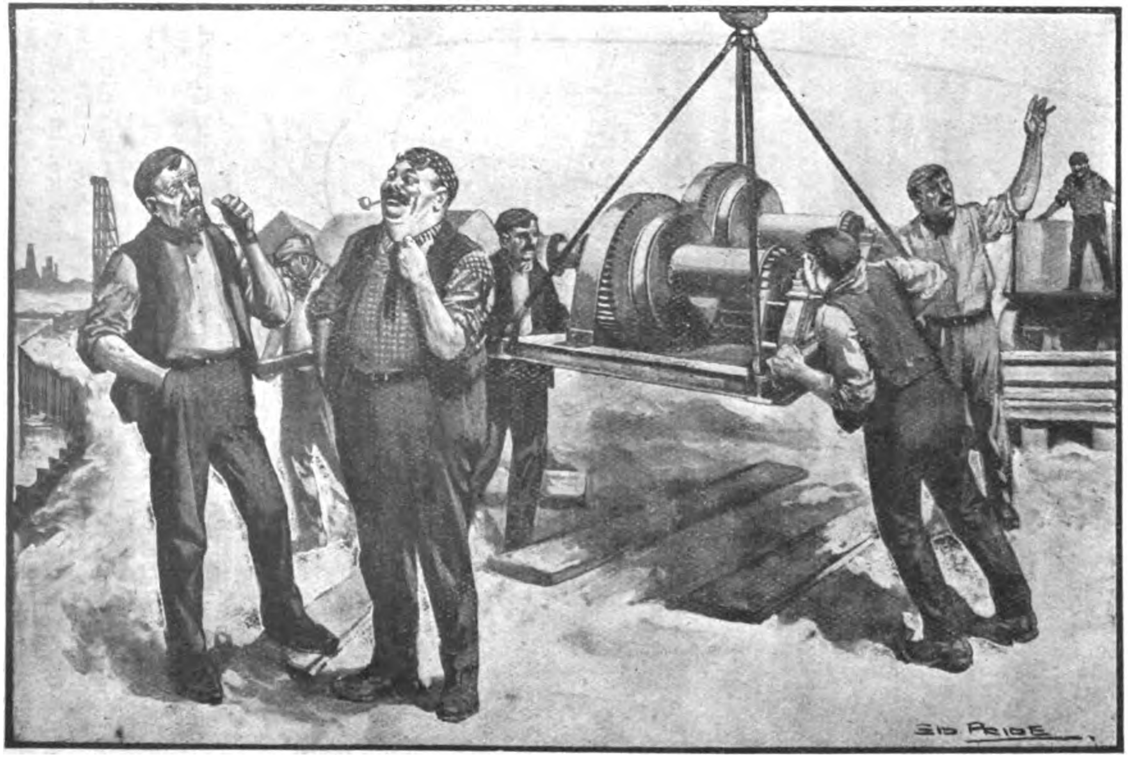
**Reinforced Concrete Roads.**—The accompanying illustrations show a road before and after being concreted. As will be seen, the road is used by very heavy traffic, which had ploughed up the original track. This track was levelled over, and without any foundation work whatever being carried out, the reinforced concrete road was laid upon it. The reinforcement used was "B.R.C. Fabric," which, it is claimed, provides its own foundation and may be laid directly on unprepared ground. The road, which is giving every satisfaction, was constructed for the Gum Tragasol Co., Ltd., at their works at Hooton, and was laid under the supervision of Mr. F. Davies, district surveyor.





**Proposed Reinforced Concrete Road for Lampeter.**—The reconstruction in reinforced concrete of Station Terrace, Lampeter—a road subject to heavy traffic—has been proposed by the borough surveyor, Mr. R. W. Ashman, and will be considered by the Streets Committee of the Corporation.

THE BRITISH STEEL
PILING CO.,
DOCK HOUSE,
BILLITER STREET,
LONDON, E.C.3.



"The WINCH that NEVER fails."

'ARRIS.—What yer looking so blue about? You can get on with the job now they've sent us this 'Zenith' Winch, there'll be no more breakdowns.

**New Methods and Materials.**—The following materials and new methods of construction have been approved by the Standardisation and Construction Committee of the Ministry of Health during the past month :—

*Bangers Concrete Construction Co., Ltd., Constitutional Buildings, East Grinstead.*—1. Reinforced concrete roofing tiles, made 3 ft. long by 1 ft. wide and about 1 in. thick, interlocking with each other, and arranged with a continuous lug to hook over a rolled steel joist or grooved wood purlin. The tiles are self-fixing, and no nails are required.

2. A concrete building block, made in two thicknesses, and fitted with a steel handle for fixing, the handle being removed when the block is laid. By this means both thicknesses of the cavity wall are formed in one operation.

*Major W. O. Pearce, Russell Hotel, Russell Square, London, W.C.*—A system of reinforced concrete construction consisting of pre-cast slabs with flanges at the ends, which fit together, and, with reinforcement grouted in, form stancheons. The blocks interlock at each course, and the vertical steel rods are reinforced with stirrups at each course bedded in the grouting.

*The Combined Concrete Construction Co., Ltd.*, 23, *Strutt Street, Manchester.*—A combination of hollow tiles and concrete, the outer walls being built of two thicknesses of hollow tiles 4 in. thick, having a 1-in. cavity between them, filled in with thick cement grout. Similar tiles are used for floor construction in connection with T-irons, the spaces between and over the tiles being filled in with fine concrete and forming a series of T-concrete beams.

*The Self-Sentering Expanded Metal Works, Ltd.*, 2, *West Street, E.C.*2.—The " Trussit " system of construction. A method of using " Trussit " reinforcement in the external thickness of a concrete wall, approved, subject to the reinforcement being embedded in plaster or fine concrete for a thickness of at least ½ in. on each side.

*J. L. Aldridge*, 3, *Highland Road, Earlsdon, Coventry.*—A form of concrete block, having a series of studs on the top edge and corresponding sinkings on the bottom. It is claimed that this automatically interlocks and expedites the building of the wall.

*Stewart & Partners, Ltd.*, 12, *Berkeley Street, W.*1.—Pre-cast concrete with pre-cast reinforced columns, built up in sections. The beams at first floor and roof carrying loads are formed of *in situ* reinforced concrete. The spaces between the stancheons are filled with thin slabs, forming a cavity wall, the external slab being of ballast concrete, and the inner of clinker concrete.

*B. Maddock, Estate Office, Elton Hall, Peterborough.*—" Fibro " Concrete building block. A concrete block made in the form of a hollow box, the centre of which is filled with compressed fibre, which can be of straw or other similar light material. This filling forms the core on which the block is moulded, and if made with concrete of the proper aggregate and proportion of cement the wall of the box can be reduced to 1 in. in thickness.

*The Lightning Construction Co.*, 64, *Victoria Street, London, S.W.*1.—A system of reinforced concrete construction, with pre-cast reinforced stancheons and beams, having poured connections. The walls are formed with two thicknesses of black corrugated iron sheeting, having 1 in. mesh wire netting clipped on each outer surface and forming a cavity core for a 3-in. concrete slab. The corrugated iron sheets are dipped in a mixture of cement grout and Matalow before the concrete is applied. There will be a physical tie between the inner and outer skins of the concrete, so that in the event of the corrugated sheets perishing the structure of the walls will remain intact. The roof and floors of the building are formed of concrete, reinforced with B.R.C. fabric.

*W. Calway, Swansea, Wales.*—The " Calway " system consists of moulds with either fixed or travelling cores, in which the concrete is consolidated section by section and course by course until the entire wall is completed in one piece.

*J. McKeown*, 66, *Grove Road, Rock Ferry, Cheshire.*—A system of concrete cavity walling, in which standardised shuttering is employed. The shuttering for the inside of the wall is formed to the full height of the house, slotted to receive the floor joists. Outside shutters are then fixed between the standards in heights of 18 in., filled up with concrete one over the other. These shutters are held in position by steel turnbuckles, and the lower shutters can be removed as soon as the concrete is set, and re-used for the upper portion of the house.

*C. S. Boswell, " Westbrook," Barrington Road, Crouch End, London, N.*8.—A system of concrete construction with building blocks of the full thickness of the wall, and having both vertical and horizontal perforations to ensure a continuous air cavity.

*R. C. Littlejohn, Fore Street, Northam, Devon.*—A system of concrete block manufacture, for making blocks in accordance with the Ministry's Building Specification for Cement Concrete Building Blocks on the site where cottages are to be erected.

*J. Ormrod & Son*, 6, *Coopers Row, Waterloo, Liverpool.*—A system of concrete block construction, with continuous vertical cavity throughout the wall, the standard size of the block being 18 in. by 6 in. by 9 in.

*Arthur Wood*, 3, *Cromwell Road, Bill Quay-on-Tyne.*—A system of concrete block construction, using bonding blocks the full thickness of the wall, which dispense with wall ties. These blocks are hollow, and alternate in the wall to form a continuous air cavity.

*S. W. Mobbs, Borough Surveyor, Town Hall, Lowestoft.*—The " Lowestoft " system of concrete building, in which flanged blocks are used for two faces of the wall, the flange being continuous on the bottom edge or bed of the block, the block being L-shape in section. The blocks for outside are made of ballast concrete and for the inside of clinker concrete. The flanges of the blocks butt together on the bottom edge and form a continuous trough, which is filled with weak concrete.

*W. Baylis & Co.*, 240–241, *Dashwood House, New Broad Street, London, E.C.*3.—The " Bayliss " machine is a portable pressure block-making machine for making concrete blocks. No tamping by hand is needed.

*Bell's United Asbestos Co., Ltd., Southwark Street, S.E.*1.—A system of concrete block construction having a continuous cavity between the walls which are tied together with ordinary galvanised wall ties. The blocks are made with an asbestos cement face, returning 1 in. round the edges of the blocks, and the necessity of external rendering and internal plastering is dispensed with.

*H. E. Dakin, Ltd.*, 31–33, *High Holborn, W.C.*1.—A system of steel shuttering framing the house, the shuttering being lifted course by course as the work proceeds.

## NEW COMPANIES REGISTERED.

**Tarmac (South Wales), Ltd.** (163,689).—Registered February 4th, 1920. Tar-concrete road metal manufacturers. Nominal capital, £50,000 in 50,000 £1 shares. Directors to be appointed as to one half by Tarmac, Ltd., and one half by Guest, Keen & Nettlefolds, Ltd. Remuneration of directors, £1,200, to be divided. Subscribers: J. H. Jolly, 19, Portland Road, Edgbaston, Birmingham, and D. G. Comyn, Penn Fields, Wolverhampton.

**Victory Concrete Block Company, Ltd.** (163,799).—Registered February 7th, 1920. 33, High Bridge, Newcastle-on-Tyne. Concrete block manufacturers. Nominal capital, £10,000 in 10,000 £1 shares. Directors: H. Broadbent, The Grove, Edgerton, Huddersfield; G. B. Tobiesen, Westwood House, Ebchester; G. Nelson and W. T. Temple, 33, High Bridge, Newcastle-on-Tyne; and J. W. Deuchar, Eldon Square, Newcastle-on-Tyne. Qualification of directors, 500 shares; remuneration to be voted by company.

**Maurice Adams Concrete Construction Co., Ltd.** (163,213).—1, Fore Street, E.C. Registered January 23rd, 1920. To carry on the business of concrete building manufacturers. Nominal capital, £10,000 in 10,000 shares of £1 each. Directors: Adams, W. H. D. Clarke, and A. W. Hall. Qualification of directors, £50; remuneration, £100 each.

## PATENT APPLICATIONS PUBLISHED.

No. 126,612.—A. M. Cramer: Casting hollow walls.

No. 136,877.—H. E. Gilford: Wall construction.

No. 137,138.—A. O. Thomas: Building blocks and wall construction.

No. 137,139.—R. Russell: Reinforced composite material.

No. 137,221.—J. H. Connelly: Ties for reinforced concrete work.

No. 137,226.—A. Mackenzie (Aktiebolajet Termit-Beton & L. Ljungberg): Concrete floors and roofs.

No. 137,415.—P. Yorke & Standard Building Construction Co.: Construction of silos.

No. 137,566.—J. N. Lester: Ferro-concrete gravestones.

No. 137,604.—A. C. Freeman & E. J. Elgood: Reinforced brick-work and block-work.

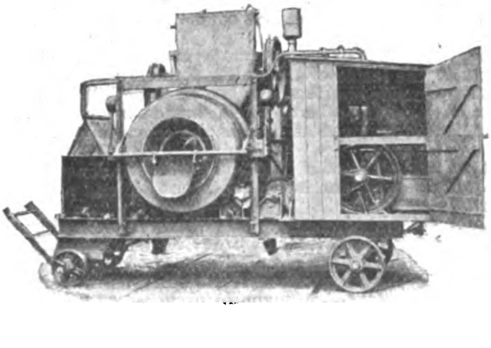
No. 137,726.—C. Marques: Building blocks.

No. 137,730.—C. Marques: Fire-place lintel of reinforced concrete.

No. 137,878.—F. Boehm, Ltd., & C. A. Reihl: Paint oils suitable for cement and concrete.

No. 137,901.—F. W. Kiddie: Concrete mixing machines.

No. 137,969.—N. Pemberton-Billing: Construction of walls.



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# CONCRETE
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APRIL 1920. VOL. XV. No. 4.

*A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.*

*ISSUED MONTHLY*

## CONTENTS.

Editorials.

Reinforced Concrete Work in Chile—Tanks at Toconce.

Concrete Cottage Building
Cottages at Amesbury.

New Formulæ for the Economical Design of Rectangular Beams, particularly as regards Shear Resistance
By MAJOR JOHN C. GAMMON, O.B.E.

Reinforced Concrete Sea Walls on a Treacherous Clay Foundation.
By PROF. E. R. MATTHEWS, Assoc.M.Inst.C.E., etc.

Metallised-Cement Decoration

The Causes of Cracks in Concrete Pavements and How to Prevent Them
By A. E. WYNN, A.M.Am.Soc.C.E.

The Story of a Concrete Road, Told in Pictures.

The Behaviour of Reinforced Concrete Columns under Fire Test. Part II.
By WALTER A. HULL, U.S. Bureau of Standards, Pittsburg, Pa.

Recent British Patents Relating to Concrete.

Two Recent Examples of Reinforced Concrete Construction in America.

Recent Views on Concrete and Reinforced Concrete.
Reinforced Concrete Fence Posts. By E. F. GRIMSHAW.
Concrete Roads.
The Practical Uses of Concrete. By OSCAR FABER, O.B.E., D.Sc., etc.

Concrete Shipbuilding.
By ALFRED B. SEARLE.

Concrete in Theory and Practice.
By OSCAR FABER, O.B.E.

Questions and Answers Relating to Concrete.

Memoranda.

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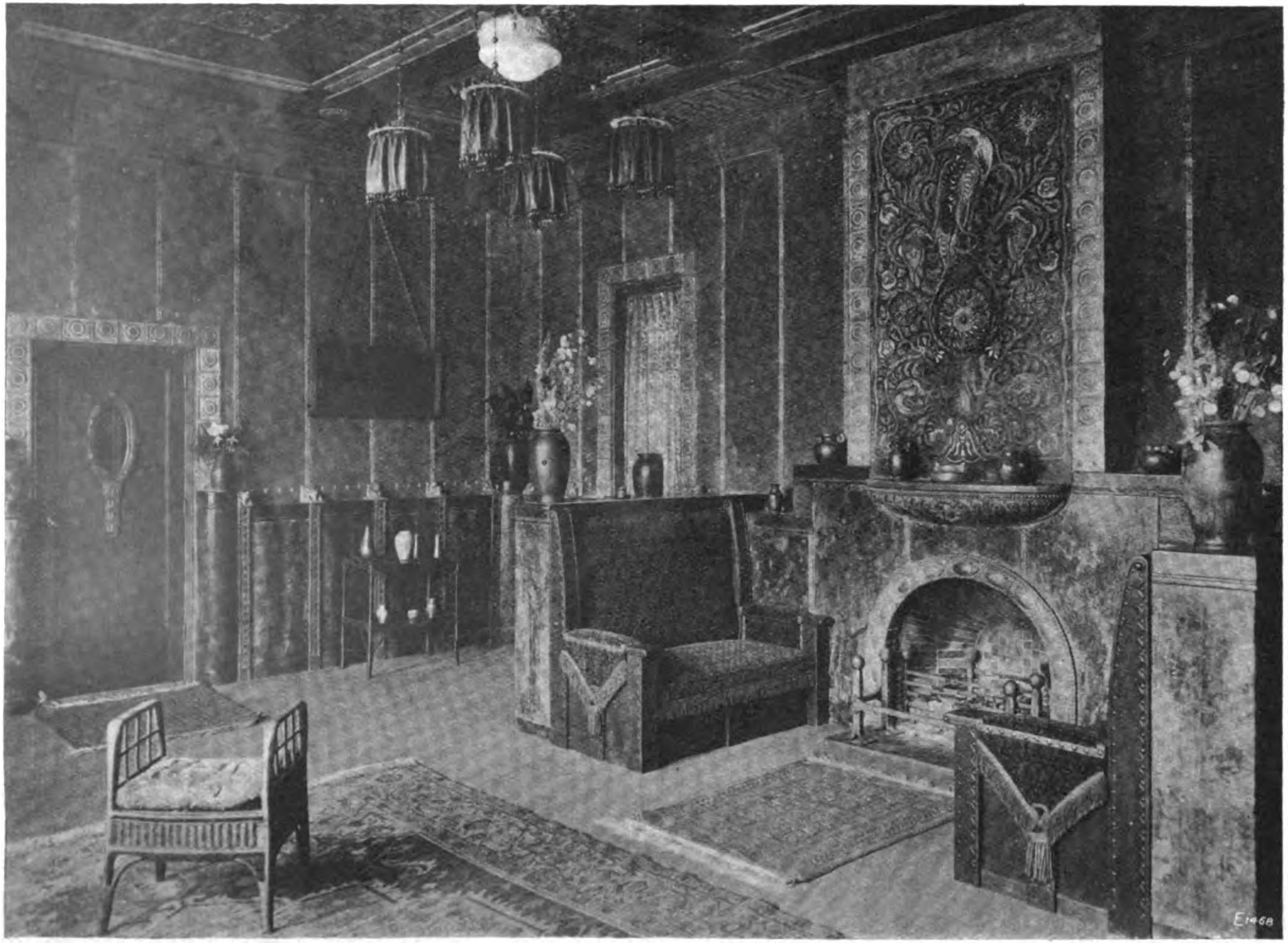

Metallised-Cement Decoration.
(*See page* 251.)

CONCRETE
AND
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# EDITORIAL NOTES.

## THE AMERICAN CONCRETE INSTITUTE.

A most extensive programme was drawn up for discussion at the Annual Convention of the American Concrete Institute, which took place towards the end of February, and it is interesting to note how every aspect of concrete construction was studied and dealt with. As in this country, so in the United States, the housing problem is a pressing and urgent one, and the Institute devoted a considerable part of the Convention's time to the consideration of the use of concrete to assist in solving the shortage of houses. Several papers were read and a number of reports presented, of which we shall publish extracts in due course. The surface treatment of concrete, concrete floors and roofing tiles all came up for full discussion. Another point which called for much attention was the question of concrete roads. The increasing use of concrete for roads has led to many developments in the United States, and a large number of papers and reports were contributed dealing with the question from every point of view. A report of considerable importance was presented on shear. The question of standardisation of structural shapes and sizes was also considered.

It is perhaps worth while making some passing reference here to an interesting address given by Mr. Irving K. Pond, past-president of the American Institute of Architects, entitled, " Concrete, its Use and Abuse." In the course of his paper Mr. Pond recommended that those interested in the development of concrete as a worthy building material, should " treat the product with respect, avoid imitations and recognise limitations, which attach to all materials as well as to all men, and to work within these limitations." In the author's opinion it was the very fact that concrete can be manipulated in so many different ways, which has led to many abuses in its employment, and it therefore " behoves those who can impartially survey the entire field to offer both warning and encouragement—encouragement in its legitimate use, warning against its frequent employment where other materials may be more advantageously used."

The author contended that concrete as employed by modern Americans was a new material, the science and art of which are not yet fully developed. He pleaded that " concrete is a vital material full of character," and it should be given vital forms.

The question of the use of forms in concrete construction was very fully dealt with.

Addressing himself to architects regarding the possibilities of concrete as a medium of æsthetic expression in building, the author maintained that this

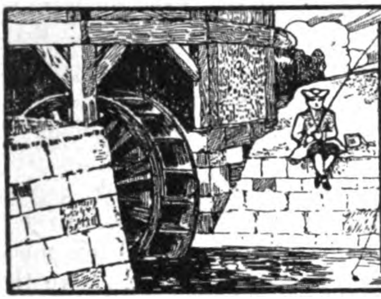
" may best be apprehended by a sincere architect with a knowledge of modern social conditions and tendencies, working in co-operation with those who know the material at first hand, and who also are sincerely working to exploit nothing but to develop the latent and inherent possibilities of a worthy material."

The *Engineering News-Record,* in commenting on the proceedings of the Convention, describes concrete " as a changing science," for the report of the proceedings seems to indicate that even in America, where this material is used on a far wider scale than here, there is still much dissatisfaction as to our knowledge regarding it. Seeing the amount of attention and study the question receives in America we venture to suggest that, in view of the extensive building-operations that must be undertaken in this country and bearing in mind the shortage of all building materials, the various aspects of concrete reconstruction and design call for much fuller consideration over here than they have received up to the present.

### THE MARKET FOR CONCRETE PRODUCTS.

Every successful industrial business enterprise must obviously be based on the principle of creating the supply of some product for which there is a large demand, and when the demand exists large profits are bound to accrue if the manufacture and supply are organised and carried out in an efficient manner. The large demand for concrete work of all kinds does and will exist for many years, and at the present time the demand exceeds the supply. A good market, therefore, exists for concrete products ; and, furthermore, the market is an extending one, which will afford good business prospects without calling upon the manufacturer to make extensive additional outlay. A great advantage in concrete work is that the raw materials required are easily obtainable in large quantities, and the production of many different types of goods is possible without the necessity of obtaining special materials which may cause delay and unknown expense.

Great possibilities exist in the building industry generally, but the greatest of all is that offered by concrete construction and products of all kinds, and contractors and specialists who develop this branch of their business will undoubtedly reap a good financial harvest during the next few years, as we have just entered what may rightly be termed the " Concrete Age."



# REINFORCED CONCRETE IN CHILE.

## TANKS AT TOCONCE.

*In a recent issue of this journal we made a short reference to some reinforced concrete work in Chile. We have now been able to secure fuller information of this work, and we publish below some particulars and illustrations which have been kindly forwarded to us by Mr. G. H. Bayles, assistant resident engineer on the works.—ED.*

THE use of reinforced concrete is now so general that any discussion of its comparative merits would be out of place; nevertheless, the question often arises whether or not it is cheapest, therefore best, for any given construction. That expression does not mean cheapest in first money cost only, but, everything being considered, whether it represents the best investment for the owner. At other times circumstances rule out one or another material of construction, and the engineer has no choice but to use what comes to hand. In the case here described the war had cut off supplies of steel plates, and so seriously delayed the deliveries of wood staves that the construction was practically limited to reinforced concrete. Aside from that the owner had already built a number of large acid sumps, huge leaching vats, some buildings, and one water reservoir of reinforced concrete, so that there was no question of its being a satisfactory material for the purpose.

The work was for the Chile Exploration Company, and located near that company's plant and mine at Chuquicamata, Chile, and was built by the company's engineers as part of a new fresh-water supply.* The location is inland from the great Chilean nitrate fields in the heart of the world's driest desert. Barrelled cement that lay unprotected in the open for years showed no appreciable deterioration. The specification was for a storage of 3,000 metric tons of water. The choice was between a reservoir excavated in the earth and lined with concrete and different styles of concrete tanks. The reservoir, being in seamy, solid rock, proved by careful estimates to be most expensive, since, because of the seamy nature of the rock and the frequent, if light, earthquakes, a concrete lining would have been necessary.

Then came the question of type of concrete tank. The sumps, vats and reservoir already in use were either flat slab walls on buttresses or of the cantilever wall type, and all were rectangular. Several estimates on preliminary plans showed a cylindrical form would be more economical. To allow for facility in cleaning or repairing the tank it was decided to make two tanks to give the required storage—that is, 1,500 metric tons each. This proved more costly, but was considered more desirable. Estimates made on this size still were in favour of the cylindrical form, and such type was consequently adopted. Estimates were then prepared for tanks—including excavation, a very important item there—varying by 2 ft. intervals from 8 to 24 ft. in height, and 18 ft. net height (20 ft. gross height) was found most economical. This gave a diameter of 61 ft. 6 in.

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* *Eng. News-Record*, Sept. 25, 1919.

*The location*—the first tank in a little gulley exactly on top of the gap in the main ridge, and the second a little way down the same gulley to the west—is three miles from the company's railroad leading to the mine, and five miles from the plant warehouse and cement storage yard, and a 1,000 ft. above the latter. That meant that great care must be used in designing to avoid excess hauling and in order to reduce the labour at the job to a minimum. Every item was decided after alternate estimates had been prepared in the light of available information. To save transportation of men, a labourers' camp was established at the site. Carpenters, except three or four who looked after the forms during concreting, being needed only a short part of the time, were transported in trucks or wagons from the railroad to and from the job.

There was only a mule trail most of the way from the railroad to the site, and considerable grading was required to make it into a usable car road. The original intention was to use some new 120 h.p. tractors and trailers for the transportation, and they were used for hauling forms and some other materials; but the trailers, with their low wheels, proved unsuited to the country, and it was necessary to resort to the native cart, a large, high-wheeled, three-ton affair drawn by six mules working three abreast. A 1½ in. pipe-line 6,000 ft. long was laid and a 3 h.p. triplex electric force pump installed at the mine tank to supply water, and thus save hauling. The side of a little knoll just above the upper tank was graded off as a site for a watchman's house, and used temporarily as a material storage yard and site for the mixer, water tank and cement storage. It was not large enough to hold the whole supply, but served very well for a sort of reservoir, and the carts were kept going constantly during the work.

*The design of the floor* was simple. Being on solid rock, subject only to shrinkage and possible earthquake stresses, it was necessary to depend on empirical formulæ. One-fourth of 1 per cent. steel reinforcement in each direction was provided. The wall reinforcement was designed to act as hoops, and sufficient steel was provided at the connection of the wall to the floor, so that, acting with the concrete in shear, it would resist the outward thrust of the water pressure. Later, the amount of reinforcement in that section was increased to provide against the cantilever action caused by the elongation of the hoop reinforcement under stress. Other vertical bars, reaching to the top of the tank wall, are for provision against cracking on construction joints and for holding the hoop steel in place. The sizes were selected from a stock of ½ in., ¾ in. and ⅝ in. bars, to combine light weight with proper spacing and ease of handling. All cutting and bending were done at the plant, and the various shapes were tied in bundles. At first glance the walls would appear rather thicker than necessary, but even against the high cost of hauling the greater rigidity of the tank ring was thought very desirable, though sufficient steel was provided to resist all tension in the ring, the concrete does take tension, and thus reduces the cantilever action at the base; and the workmen available were so unskilled in concrete work that it was doubtful if they could get good results with forms any closer together than 9 in. It was only after months of similar work that a concrete gang was able to produce good results in 5 in. walls.

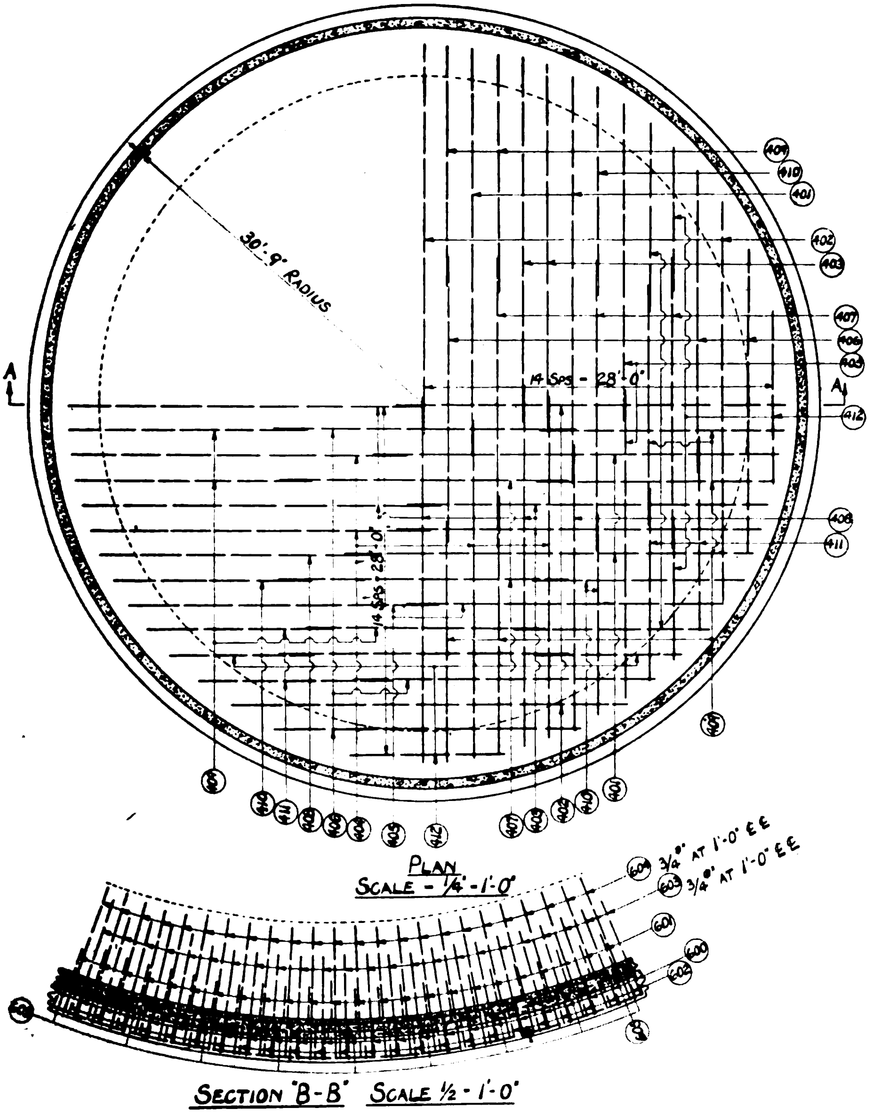

Fig. 1. Plan and Section of Tank showing Reinforcement.
Reinforced Concrete in Chile.

Several tentative designs of forms were prepared. The one finally selected was so designed that all the work on it, except the simple placing of the parts, could be done at the plant, and the parts were light enough and small enough for easy handling. It figured very close to the lowest in cost in the preliminary estimate, and had the advantage of having been designed by the man who was to build it.

*The concreting plant* was very simple. A 4 cu. ft. capacity gasoline-driven concrete batch mixer; an old boiler for water storage, and another for heating water; a section of worn-out 15 in. steel pipe for heating stone and sand; a few wheelbarrows, shovels, sharp and flat-pointed rods for puddling, and some water buckets. A spout of old corrugated sheet iron ran from the mixer to the tank, the grade varying from 25 to 60 per cent., depending on the height of the forms.

The coarse aggregate for the concrete was tailings from the ore reducing plant, screened and reproportioned so that 1 cu. ft. of cement was used for every 4½ cu. ft. of concrete. Control beam tests indicated a crushing strength of more than 3,500 lb. per sq. in. for this concrete. It was mixed wet enough to run well in the spout, and in any case, wet enough to puddle easily, and not wet enough to cause trouble by leaking through small cracks in the forms.

The excavation being completed as nearly as practicable, the posts for form supports were erected, and then the outside ring of forms for the first lift set up. The reinforcement for the wall foundation ring, the vertical reinforcement and the hoops up to the top of that form were then placed. A 2 in. by 4 in. stop was set just below the elevation of the top of the floor and just inside the line of the wall to provide a method of tying the floor reinforcement to that of the wall and footing, and the inside wall form then placed. Concrete was first placed in the wall footing ring—except the part stopped off as described—and up into the wall forms. It was at that point that the only difficulty in getting perfect concrete developed. The mortar was allowed to leak out from places in the first two feet of wall, the action going on slowly after the concrete was poured, causing some honeycombing and, later, leaks in the tank. A stiffer concrete and more puddling prevented this almost entirely in the second tank. After the forms were removed the honeycombed part was carefully picked out and refilled with mortar and stone, well hammered in, and then the inside surface plastered ½ in. thick for a height of 2 ft.

The second day the surface inside the forms was covered with a wash of neat cement, and concreting continued to the top of that lift of forms. No hopper was used to catch the concrete at the lower end of the spout, but a labourer with his shovel held the concrete in the end of the spout while one wheeler moved on with his load and the next took his place. There were four wheelbarrow loads to a batch, and never any loss or delay at the spout. Only one wheelbarrow load of concrete was allowed to be deposited in a place, and care was exercised to have a little mortar from the concrete running ahead of where the concrete was being dumped so that all new concrete was dumped into mortar, thus preventing vacant spaces between the newly placed concrete and that of the preceding round. In this way it was placed in layers approximating 6 in. in thickness, and each layer was placed before the preceding one had set.

The concrete was puddled rather than spaded with rods made especially for the purpose. They were made of ¾ in. pipe and were 10 ft. long, some with flat points and some sharp pointed. The wheeler at the handles and an extra man at the other end picked up the loaded barrow and dumped the concrete slowly into the forms, being able thus to stop whenever there was any indication that the concrete was not being properly placed or there was risk of piling it up and leaving unoccupied spaces. Two men using flat-pointed bars, and three or four with sharp-pointed bars, puddled the concrete almost as it fell, moving along as the pouring progressed, thus making the work continuous throughout the day, or until a lift of forms 6 ft. high had been filled.

The day after a form was filled that form was raised to the next higher lift. This was done by loosening the wedges at the ends of a section, attaching a block and fall and hoisting it by hand to its new place, where it was again lined up and wedged in. It required a whole day to raise a set of forms one lift, so that concreting was done on alternate days, the forms being handled on the intervening days. There being four lifts, and one day being required for the wall footing ring and another for the floor, it therefore required ten days to pour each tank.

A complete concreting gang consisted of a foreman, a fireman for water and aggregates heaters, one man handling cement, one man handling water, one wheeling sand, one wheeling stone; a "straw boss" or assistant foreman, who judged when the concrete was properly mixed, saw that proportions of materials were correct, etc., one to dump the batch and keep the spout clean, one at the lower end of the spout, five wheelers of concrete, five puddlers, one helping dump the wheelbarrows, and two carpenters keeping the forms true to line, etc.

The following labour costs are those chargeable directly to the job and do not include warehouse handling of cement, washing and screening stone and sand, etc. The heavy charge against stone, which includes sand as well, was the loading and other handling necessary where it was dumped from the cars and loaded into carts for transportation to the site of the tanks.

| ITEM. | COST.<br>$ | |
|---|---|---|
| Cement | 0·547 | per cu. yd. of concrete. |
| Stone | 2·040 | ,, ,, ,, |
| Mixing concrete | 0·950 | ,, ,, ,, |
| Placing concrete | 1·070 | ,, ,, ,, |
| Forms | 4·120 | ,, ,, ,, |
| Reinforcement | 2·350 | ,, ,, ,, |
| Finishing concrete | 0·170 | ,, ,, ,, |
| Local plant | 0·740 | ,, ,, ,, |
| A total of | $11·987 | |

all in U.S. currency. The total amount of concrete in the two tanks was 467 cu. yd.

## PIPE WORK.

There were two interesting pieces of pipe work in connection with this work. These are the overflow from the main pipe-line and the overflow from the tanks. In designing the pipe-line overflow the objects were to prevent shutting off the flow from the line at the tank, thus raising the pressure in the lower part of the fifty-mile inverted siphon far above the ability of the pipe to resist, and to make it unnecessary to shut off the flow at the head of the line, thus emptying the line and causing possible trouble in refilling it. With these objects in view an inverted "U" was made in the line just beside the first tank—

the elevation of the ground being only a little above the middle height of the tank—with an overflow from the top of it, the top of the "U" being made 7½ in. below the highwater mark in the tank, thus preventing loss of stored water in case of a rupture of the pipe-line, and the top of the overflow pipe level with the top of the tank. This gave a fall from the overflow to the tank, making the usual allowances for bends and fittings 50 per cent. greater than

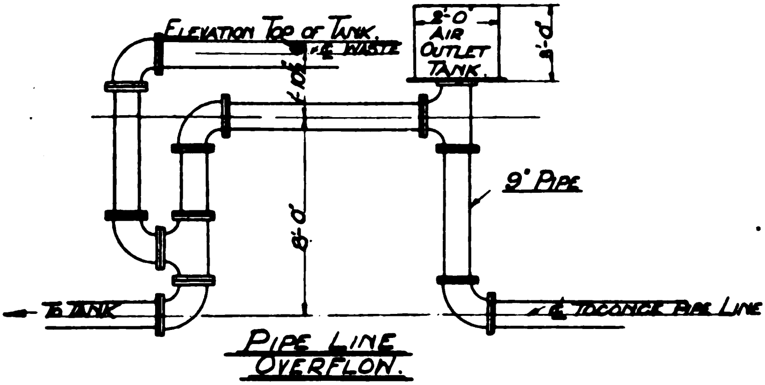

Fig. 2.

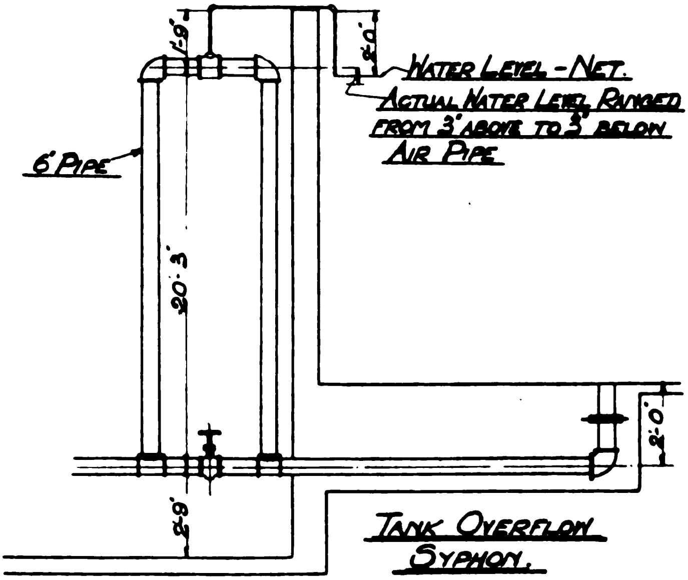

Fig. 3.

Reinforced Concrete in Chile.

the calculated hydraulic gradient of the pipe-line to that point. The hydraulic gradient did not prove to be as steep as calculated (no doubt it will reach the calculated gradient during the life of the line), and air was taken into the line at the hump near the springs. This air was entrained with the water, greatly reduced in volume, no doubt, by the high pressure in the inverted siphon, and, expanding as the pressure was reduced, filling as much space as it approached the tank as at the beginning of its long journey, and so producing an air lift that made the overflow practically inoperative; that is, the air rising through the overflow pipe carried the water with it in preference to dropping down through the continuation of the pipe-line to the tank; and water began to overflow when the level in the tank was 3 ft. below highwater mark. Much air was carried along with the water into the tank, changing the weight of the liquid, and at the same time changing the hydraulic gradient of that part of the line.

To remedy that the overflow shown in the accompanying diagrams was designed. In practice the air holds the level of the water in the " air outlet tank " to between half a foot and 2 ft. from the top of that tank; only a little air rises through the overflow pipe, and the tank fills to calculated highwater mark before overflow begins.

The tank overflow was designed as shown in *Fig.* 3, and worked exactly as expected, except that the 1 in. air pipe was found to be not quite large enough. The object of the design was to provide an overflow that would be free from floating obstructions, that would have a capacity much greater than the inflow, and that would operate quickly to maintain highwater level between reasonably close limits. This was obtained by using a 6 in. pipe siphon, beginning in the bottom of the tank, rising to highwater level, and falling again below the bottom of the tank, so that the overflow when siphon action had begun would be equivalent to a flow directly from the bottom of the tank. The 1 in. air pipe connected at the top of the siphon is supposed to be closed by the rising water at the same instant that water begins to overflow through the siphon. As a matter of fact, the tanks being located in a mountain pass, where there is nearly always wind, air continues to enter the pipe, more or less, until the average level is 2 in. above the highwater mark. When the water has reached about 1 in. above that (3 in. above highwater mark) siphon action begins, and the excess of outflow over inflow is so great that within ten minutes normal highwater level is reached and air is entering the air-line, but not in sufficient quantity to stop the siphon, and the overflow continues until highwater level in the tank drops about 3 in. below the end of the air-line. This condition was considered satisfactory, and no change was made in the pipe. If closer regulation is desired it can be obtained by substituting a larger pipe for the present one.

The connection at the bottom of the siphon, closed by a gate valve, is put in so that the same outlet may serve as a clean-out pipe. In the first tank this connection is to a different line, the overflow from that tank being into the main line to the second tank. The overflow from the second tank is on to the ground.

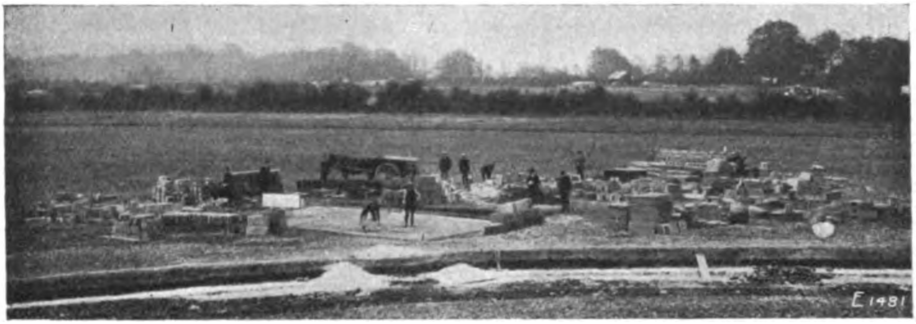

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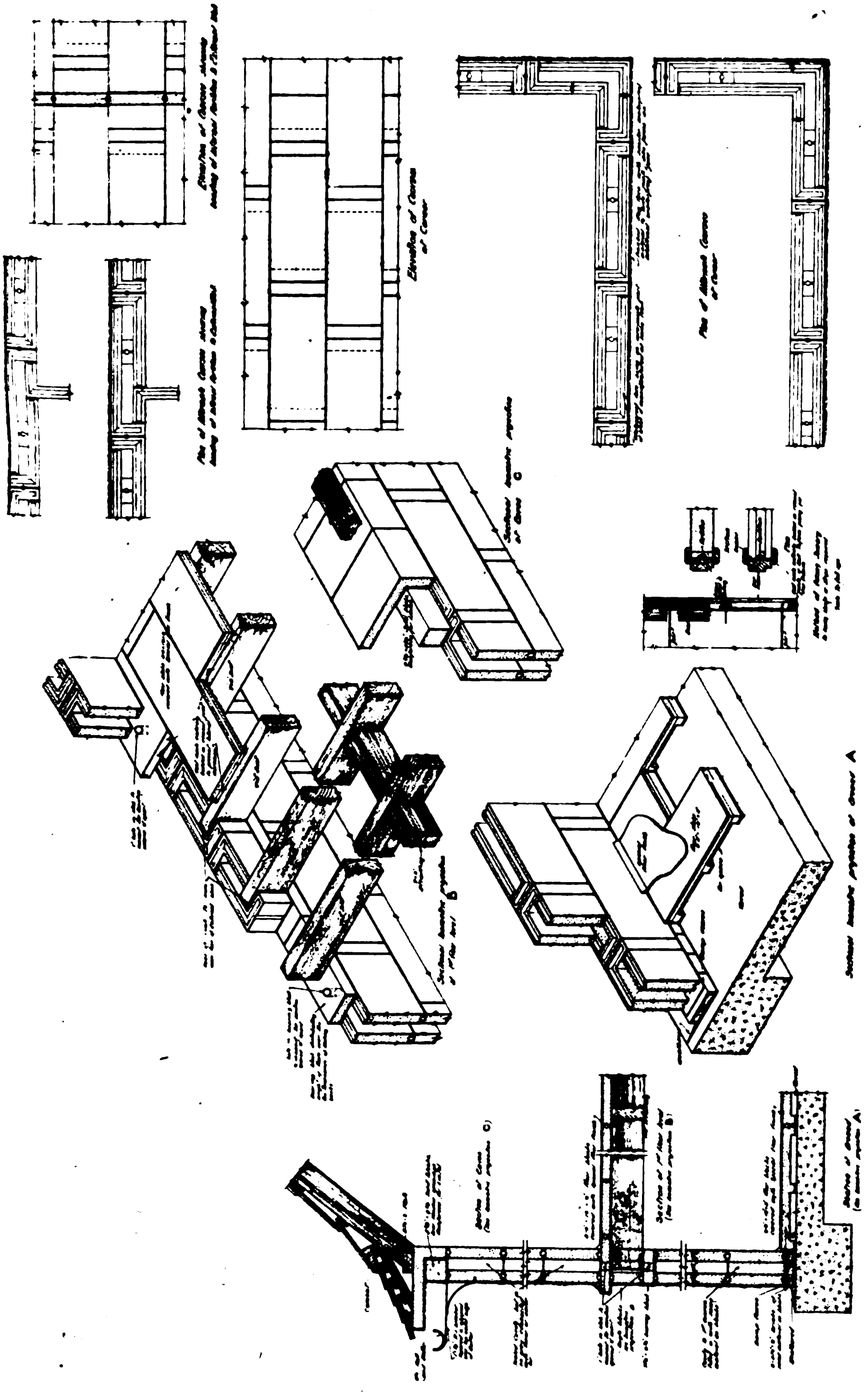
Fig. 1. General View of Site showing Concrete Foundations.

# CONCRETE COTTAGE BUILDING.

## COTTAGES AT AMESBURY.

The methods of manufacturing pre-cast concrete blocks for cottage building vary, but, for the most part, they consist of some kind of machine for pressing a semi-liquid or semi-dry mixture into the required shape ; the block being—at the time when it leaves the machine—sufficiently firm to retain its shape whilst drying. This method has certain distinct advantages over a liquid mixture placed in moulds in which it is allowed to dry, and of these the most important are that it generally permits of a far more rapid output, and that it economises in plant ; a block making machine and pallets replacing a large number of possibly somewhat cumbersome moulds. The great danger, however, in connection with the semi-dry or semi-liquid process is that the block may dry too rapidly or unevenly, so that only an outer skin is properly formed. Two precautions can be taken against this : the blocks should not be allowed to dry rapidly, and this can be prevented either by frequent sprinkling or by placing the blocks in a damp place, and the thickness of concrete should be reduced to a minimum. Here, again, however, excessive reduction in the thickness must lead to weakness unless special steps are taken to ensure that the mixture and mixing are done with great accuracy, and unless care be taken to distribute any load, which the walls may be called upon to carry, equally over all its thickness, for it is obvious that a very thin wall demands a hollow system of construction in order to obtain adequate strength. Where, therefore, it can be ascertained that the blocks will be of sufficient strength to admit of their thickness being reduced to 2½ or 2 in., the likelihood of obtaining a more permanent structure, and one whose walls will be less liable to disentegration, and better able to withstand frost and rain, is undoubtedly increased.

A pair of cottages, of which illustrations are given, have recently been completed for the Ministry of Health at Amesbury. These cottages were erected by the Bonding Block Constructional Company, and the thickness of the walls is


Elevation of Corner
Plan of Alternate Courses at Corner
Isometric projection at Eaves C
Isometric projection at 1st floor level B
Isometric projection at Ground A
Section of Eaves (see isometric projection C)
Section of 1st floor level (see isometric projection B)
Section of Ground (see isometric projection A)

Details of Construction.
COTTAGES AT AMESBURY.

7½ in., composed of two 2½-in. skins with a 2½-in. cavity, and permission has been given by the Ministry for the use of 2 in. blocks. Before, however, deciding to build with walls of such a small cross-section, a series of tests were undertaken with the company's blocks by the British and Colonial Laboratories, the results of some of which were as follows: Contraction at 20 deg. Fahrenheit below freezing, $\frac{1}{82}$ in. in 27 in.; expansion at 120 deg. Fahrenheit, $\frac{1}{127}$ in. in 27 in. A briquette, made of coarse clinker and cement eight weeks old was cut from the solid and tested for tensile strength, it yielded to a strain of 208 lb. per sq. in. The blocks were also subjected to fire and waterproof tests.

The system of construction is extremely simple, and the ensuing explanation should be read in conjunction with the illustrations of the details shown on page 235. At the outset it should be mentioned that apart from lintels no reinforcement is employed. As the total structure is light—it is estimated at half the weight of a brick house of similar size and accommodation—no deep excavations are deemed necessary, and a raft of concrete, the precise thickness varying with the soil, is formed over the site, the thickness being increased immediately under the walls. On this the bottom course of the outer walls is built. This is composed of concrete bricks of the same thickness as the walls, and on it is placed the damp course. The wall is then built up of L-shaped concrete blocks. The normal size of these blocks is 27 in. by 12 in. by 6¾ in. Where a 2½-in. block is used the last dimension becomes 7½ in. The position of the vertical joints alternates at every two courses, thus forming a proper bond. Internal partitions are similarly bonded in to the outer walls with alternate right and left armed L-blocks.

Directly beneath the joists at first-floor level a course of bearing blocks is inserted, in this way the weight of the floor is distributed equally over the whole thickness of the wall. At the actual level of the joists a special course of blocks, whose depth is equal to that of the joists, is used, and the inner blocks are shorter according to the thickness of the joist employed. The floor itself is composed of slabs which measure 36 in. by 12 in. by 2 in. In some instances these are built so as to project beyond the outside face of the wall, thus forming a vertical string-course, there is no reason, however, why these slabs should not finish flush with the outside face. It should be observed that both the bearing-blocks and the floor-slabs, where built across the wall, are pierced with 1-in. holes spaced at 9-in. centres in order to admit of free circulation of the air throughout the entire hollow of the wall, this has an important effect in tending to keep the walls dry and healthy.

From the first-floor level the wall is continued in the same way until the eaves are reached. These are formed by building on the outer lining a solid square 4¾ by 4¾ in. block, which closes the cavity. On the inner lining, and bearing both on it and on the square block, is placed an angle block with a wide overhang which constitutes a broad and well-defined eave, throwing a bold shadow on to the face of the wall. On the inner edge of this angle block is built the wall plate on which the feet of the rafters finish, and to which they are spiked. A battened sprocket-piece then carries the tiles over the eaves. The gutter is supported by W.I. brackets which are built in at suitable intervals. The roof is covered with Vickers's interlocking concrete tiles, but ordinary tiles could be employed if they are preferred. It will be seen from the illustration of a finished cottage that, at Amesbury, the lower courses over the sprocket pieces are of ordinary tiles, while the upper part is of interlocking tiles. This mixture of the Roman tile with the ordinary tile is often met with in old work, and is very pleasant since the smaller gauge more easily accommodates itself to a bold sweep at the eaves.

The ground floor is made of 27 in. by 12 in. by 3 in. concrete slabs whose undersides are ribbed, thus the ventilation is secured between the tarred face of the surface concrete and the underside of the slabs. Both the ground and the first floor are finished with a non-conducting washable patent floor finish. The chimneys are carried up solid in concrete with fire-clay cylindrical flues. Internal plastering has been dispensed with, and the walls and ceilings are finished with cement and sand wash applied with a brush and subsequently colour-washed. This has resulted in a very pleasant textured surface.

Several photographs are reproduced showing the houses in various states of erection. In *Fig.* 1 on page 234 it will be seen that the concrete foundations have been completed. This work was carried out by two labourers in 48 hours, and was finished on September 30th, 1919, shortly after which date, it will be remembered, the railway strike began which delayed further operations until October 22nd, and this illustration shows the position of the work on October 30th. *Fig.* 2, page 238, shows the state of affairs one and a half days later, and *Fig.* 3 after a further interval of three days. The fourth course of walling was begun and finished on this day; the four courses being equal to 16 courses of brickwork. The door frames are fixed. *Fig.* 4 shows the situation after a lapse of five more working days. The walls are 8 courses high, steel window frames and sashes are fitted, and the lintels are fixed, also the ground floor fire-places are completed and the first-floor joists are being built in; during this day some of the first-floor slabs were placed in position so that the upper part of the walls might be proceeded with. The next photograph, *Fig.* 5, shows a finished house completed in 30 working days of 9 hours per day by an average of 7 men, making a total of 1,792 working man hours. It will be noticed from these photographs that a system of portable trestle scaffolding is used. The whole of the work is carried out by this means and a considerable saving is claimed therefrom by the company.

Before work is commenced, a set of detail drawings are prepared by the Bonding Block Constructional Company from whatever plans may be supplied of the proposed buildings. These include a set of sectional plans through each course, showing the exact size of every block. Such a plan is reproduced on page 240. It is from these detailed drawings that all the parts of the house are made in the workshop and delivered finished on the site, and it will be realised that if a return is to be had from all the work which is entailed in the preparation of these detailed drawings, it is necessary that the same type be used many times; the full financial advantage, therefore, of this system is only to be obtained on large schemes of 50 houses or upwards, on very large schemes it would be advisable to establish a local workshop and make the blocks on the site, more especially if suitable aggregate were obtainable, for in this way transport, which is the cause of so much delay in housing schemes, would be reduced to a minimum.

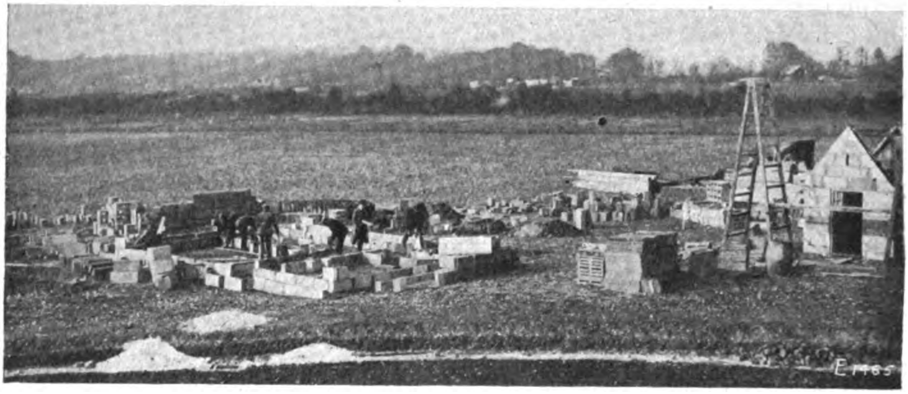


**Fig. 2.**

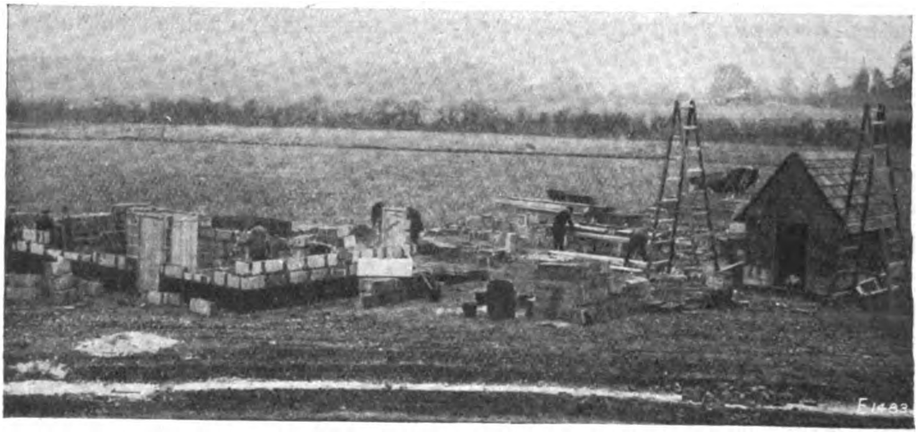


**Fig. 3.**

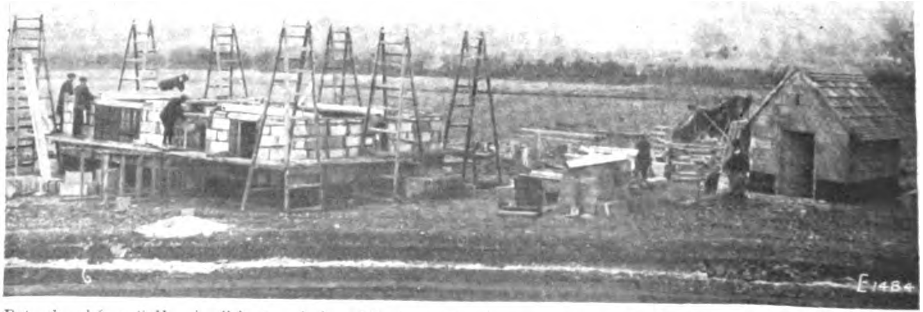


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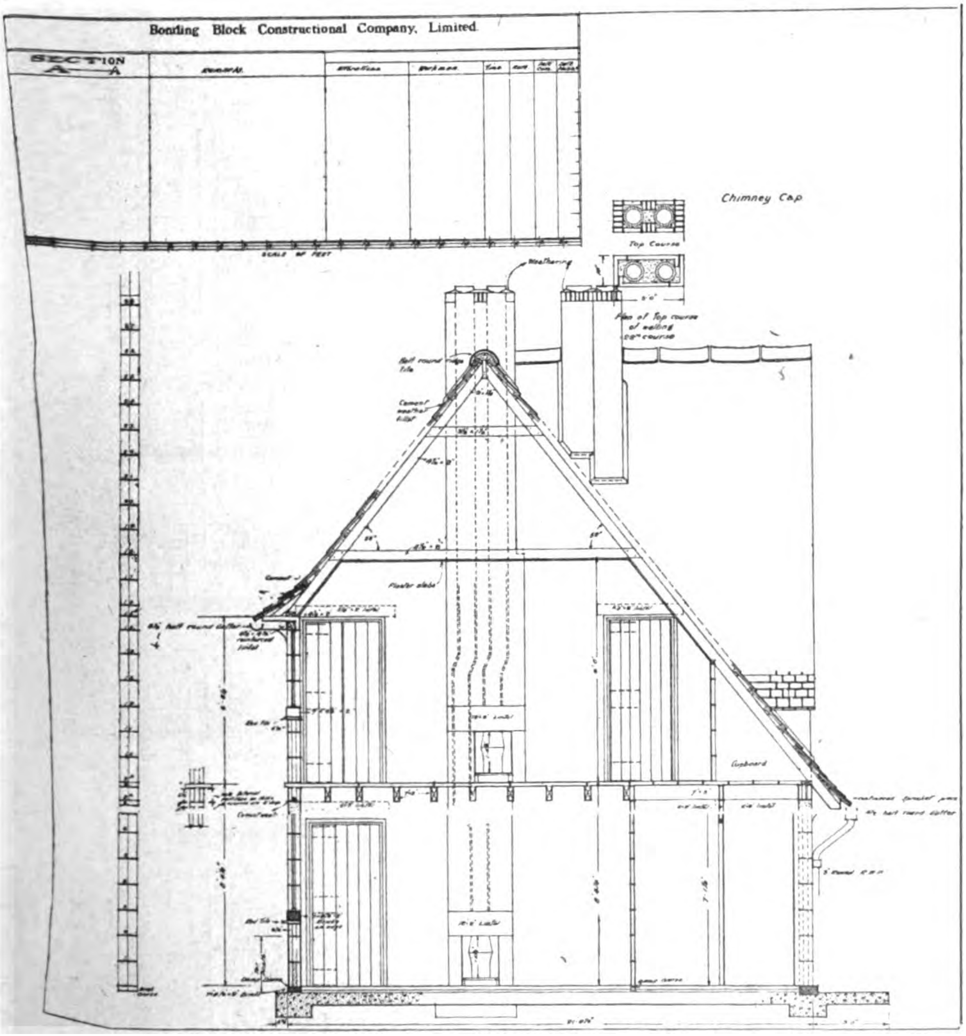
**Fig. 4.**

**Views showing the houses in course of construction.**

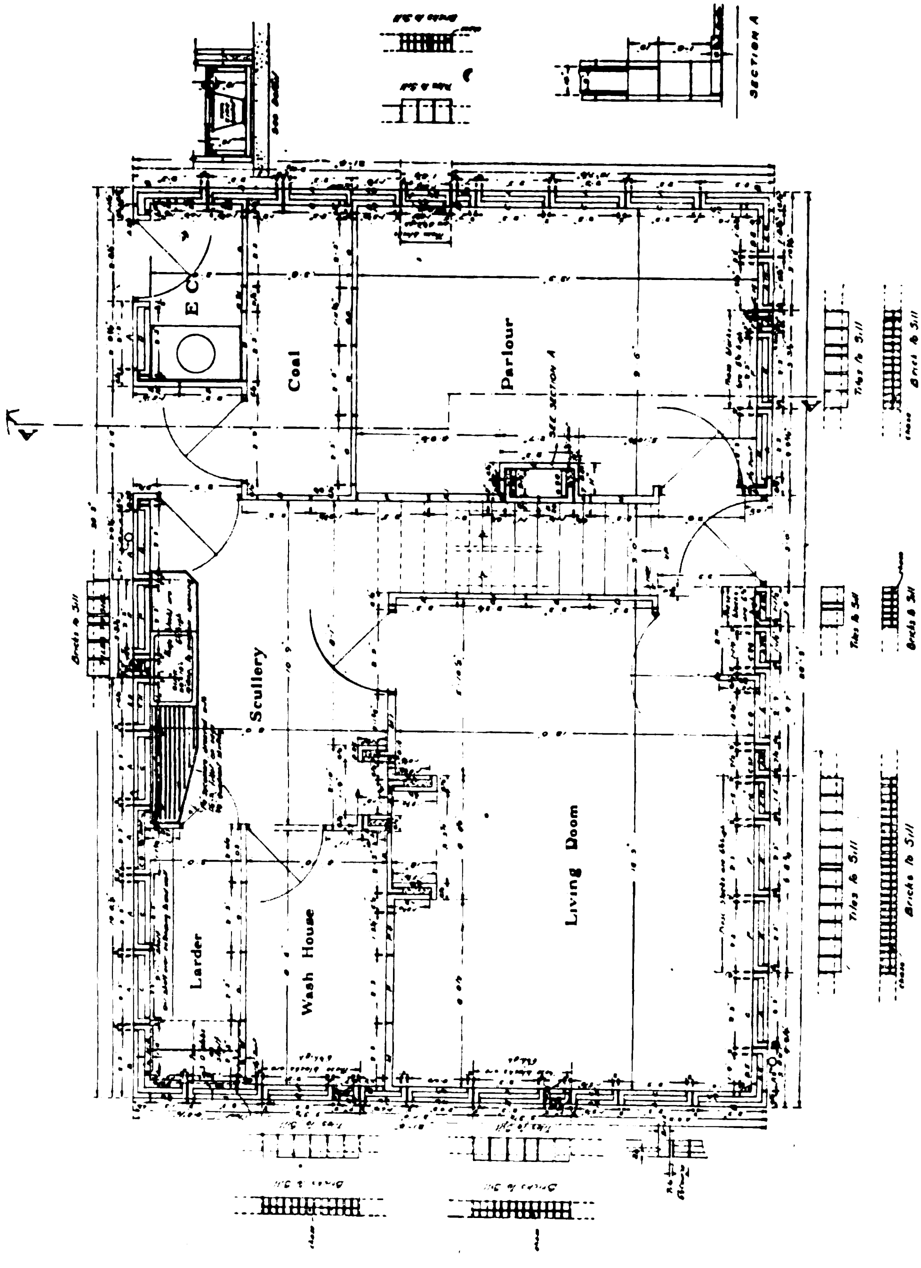
**HOUSES AT AMESBURY.**

The method of forming the chimney-breasts should be noted; it will be seen that blocks of the same shape are used for these and the cavity is filled in solid. It must be admitted, however, that the backs to the openings look dangerously thin, and this defect is particularly noticeable in the parlour, where the fireplace opening backs on to the staircase, which is, of course, of timber.



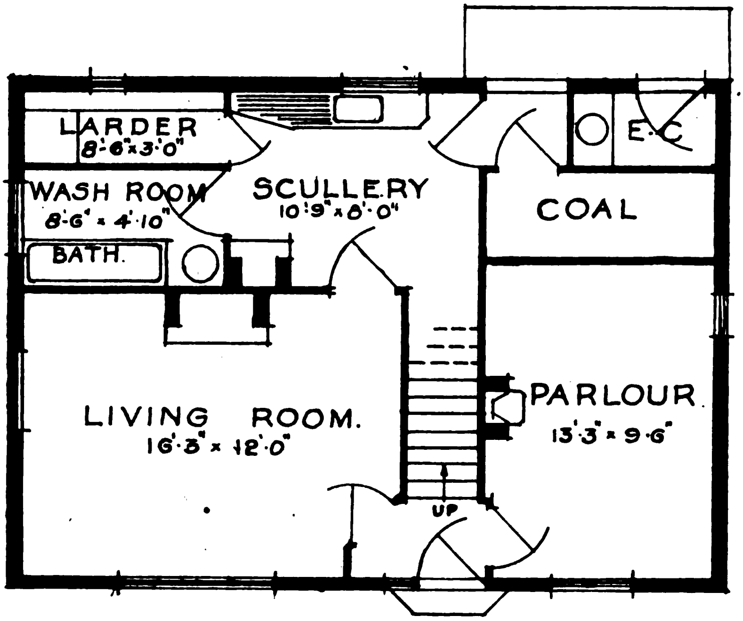
**Section AA.** see plan on page 240.
HOUSES AT AMESBURY.

All the surfaces of the blocks which are to be exposed to the weather are specially treated during the process of manufacture, a waterproof face being incorporated with the block; furthermore, on completion the walls are again treated with a similar mixture, applied liquid, which covers the joints. Where a building of such small dimensions is made of large blocks it is advisable to cover the joints, for the large unit is apt to destroy the scale and general proportion. At Amesbury the base of the wall is tarred to plinth level. A touch of colour is added by the brick and tile window cills and the brick chimney caps.

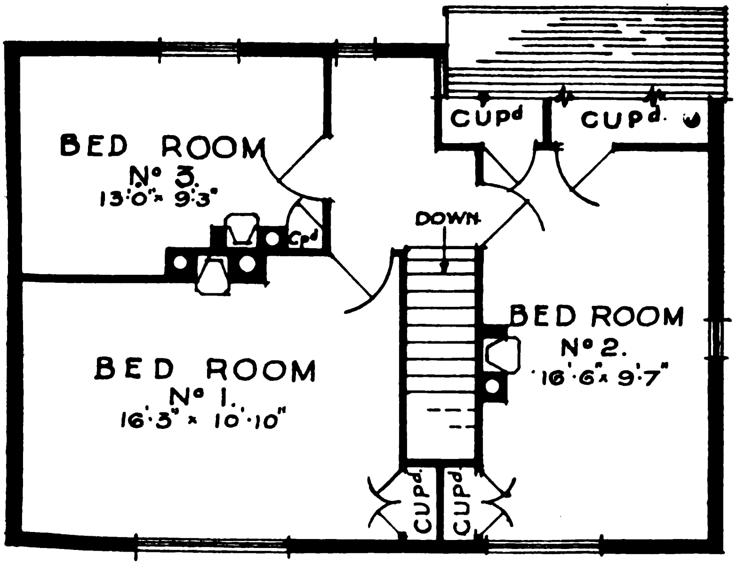


Sectional Plan.
Houses at Amesbury.

As to cost, this, as has been already indicated, must depend to a large extent upon the number of houses which it is proposed to erect, the company's claim is,



GROUND FLOOR PLAN



FIRST FLOOR PLAN.

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Houses at Amesbury.

however, a bold one. The company claim that by this method of construction a saving of 25 per cent. can be effected over a similar house built in a similar locality in brickwork.

This fact, together with the pleasant and cheerful appearance of the house, the apparent soundness of the method of construction and the ease with which it lends itself to a variety of treatments in keeping with the particular requirements of the individual or of the locality, should do much to dispel any lingering hostility towards what is, despite all protests, an ever-growing rival to the hitherto accepted materials such as brick and stone.

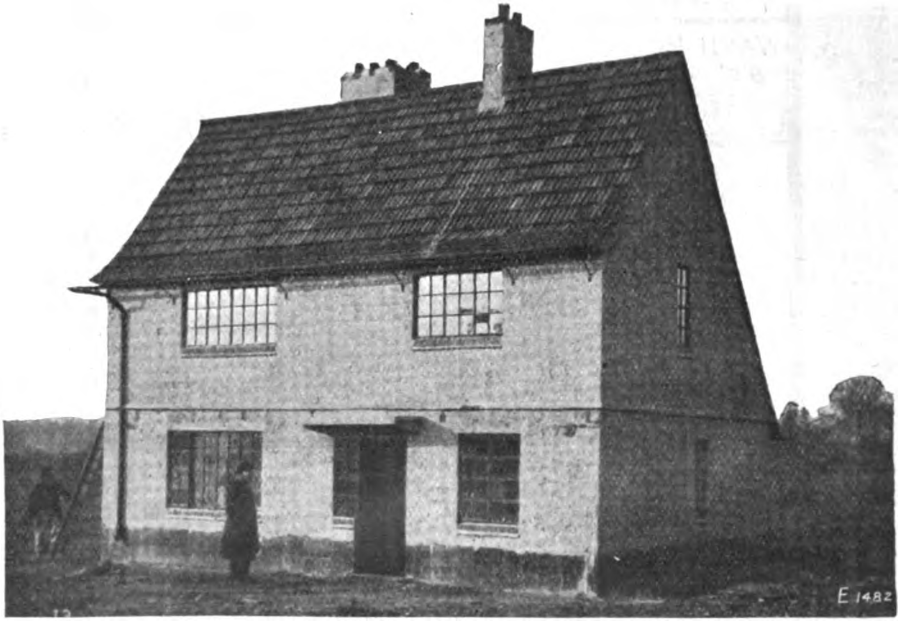

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Fig. 5. View of a Finished Cottage at Amesbury.

# NEW FORMULÆ FOR THE ECONOMICAL DESIGN OF RECTANGULAR BEAMS PARTICULARLY AS REGARDS SHEAR RESISTANCE

## Exact Condition for No Shear Reinforcement in a Slab.

By MAJOR JOHN C. GAMMON, O.B.E., B.Sc., etc.

In selecting the depth and breadth of a rectangular beam, three conditions have to be considered—viz., the resistance of the beam in compression, tension, and shear.

If $b$ be the breadth and $d$ the depth of a beam, the compressive resistance is proportional to $bd^2$, the shear resistance to $bd$. Also the tensile reinforcement required is independent of the breadth and proportional to the depth. Clearly, then, as regards tensile and compressive resistance, the deepest and narrowest beam will be the most economical. If, however, the depth becomes too great, the beam becomes weak in shear, unless it be designed overstrong in compression.

In designing rectangular beams, the designer will usually limit himself as regards shear strength in either one of two ways. Either he will limit the average shearing stress on the concrete to 60 lb. per sq. in., in which case shear reinforcement will not be required; or else he will limit the average shearing stress to 100 lb. per sq. in., which is the usually permitted maximum. The formulæ worked out below give the maximum permissible depths for rectangular beams, consistent with these conditions as regards shear strength being fulfilled. Up to the depth thus obtained, every increase of depth diminishes both the total amount of concrete necessary to keep the compressive stress below its permissible amount, and also reduces the amount of tensile reinforcement. If a depth greater than that given by the formulæ is chosen, however, there will be no saving in concrete, for otherwise the shear strength will be reduced below its permissible minimum. An increase in depth will still lead to a reduction in the quantity of tensile reinforcement; but other considerations, such as headroom, appearance, centering costs, will generally make any addition to the depth undesirable.

The object of this paper, then, is to give formulæ which will in the first place enable the minimum breadth of a beam to be calculated; and, if this breadth be adopted, to give formulæ for the calculation of the depth and tensile reinforcement.

The formulæ thus evolved prove so simple that these calculations could all be made mentally.

Finally, the application of these formulæ to reinforced concrete slabs gives an exact and definite condition that shear reinforcement need not be provided.

### ABBREVIATIONS.

Let $b$ =breadth of beam in inches.
$d$ =depth of beam in inches.
$n$ =distance of neutral axis from top of the beam in inches.
$l$ =span of beam in ft.
$w$ =weight carried per ft. run of the beam.
$W$ =total load on beam in lb.
$A_s$ =tensile reinforcement in sq. in.
$c$ =maximum compressive stress in concrete =600 lb. per sq. in.
$t$ =maximum tensile stress in steel =16,000 lb. per sq. in.
$s$ =shearing stress in concrete.

### I. SHEARING STRESS LIMITED TO 60 LB. PER SQ. IN.

### *A. Beam Freely Supported.*

(i) Designing for compressive resistance of beam :—

$$\tfrac{1}{2}\times c\times b\times n\times\left(d-\frac{n}{3}\right)=\text{bending moment}$$

$$=\frac{wl^2}{8}\times 12 \text{ in. lb.}$$

and
$$n=\frac{15c}{t+15\times c}\times a.$$

$$=0{\cdot}36d$$

$$\therefore\ \tfrac{1}{2}\times 600\times b\times 0{\cdot}36d\times 0{\cdot}88d=\frac{wl^2}{8}\times 12$$

$$\therefore\ d^2=\frac{wl^2}{63{\cdot}4b}$$

$$d=\sqrt{\frac{w}{63{\cdot}4b}}\times 1$$

(ii) Designing for shear resistance of concrete :—

$$s\times b\times\left(d-\frac{n}{3}\right)=\text{maximum shear}$$

$$=\frac{wl}{2}$$

$$\therefore\ 60\times b\times 0{\cdot}88d=\frac{wl}{2}$$

$$\therefore\ d=\frac{W}{105{\cdot}6b}\times 1$$

Equating (i) and (ii)

$$\sqrt{\frac{w}{63{\cdot}4b}}=\frac{w}{105{\cdot}6b}$$

Whence
$$b=\frac{w}{175}$$

Further
$$d=\sqrt{\frac{w}{63\cdot4b}}\times1$$
$$=\sqrt{\frac{175b}{63\cdot4b}}\times1$$
or
$$d=\frac{10\cdot1}{6}\text{ very nearly.}$$
Also
$$A\times t\times\left(d-\frac{n}{3}\right)=\text{bending moment}$$
$$=\frac{wl^2}{8}\times12$$
or
$$A_s\times t\times0\cdot88d=\frac{wl^2}{8}\times12$$
or since
$$d=\frac{10\cdot1}{6}$$
$$A_s=\frac{wl^2\times12}{8\times0\cdot88\times\frac{10}{6}\times1\times16\cdot000}$$
$$=\frac{wl}{15\cdot500}$$
or
$$A_s=\frac{W}{15\cdot000}\left(=\frac{w}{t}\text{very nearly}\right)$$

*B. Continuous Beams.*

Taking a bending moment of $\frac{wl^2}{12}$ : the following formulæ are obtained as above :—

$$b=\frac{w}{117}\text{ in.}$$
$$d=\frac{10\cdot1}{9}\text{ in.}$$
$$A_s=\frac{W}{15\cdot500}\text{ sq. in.}$$

*Example.*—Design a continuous rectangular beam to carry a load of 1,300 lb. per ft. run over an 18-ft. span.

Using the above formulæ for most economical design :—

$$b\ =\frac{w}{117}=\frac{1,300}{117}=11\text{ in.}$$
$$d=\frac{10\cdot1}{9}=\frac{10\times18}{9}=20\text{ in.}$$
$$A_s=\frac{1,300\times18}{15\cdot500}=1\cdot51\text{ sq. in.}$$

### II. SHEARING STRESS LIMITED TO 100 LB. PER SQ. IN.

*A. Freely Supported Beam.*

In the same way as above, but giving $S$ a value of 100 lb. per sq. in., the following formulæ are obtained :—

$$b=\frac{w}{485}\text{ in.}$$

$$d = 2{\cdot}75\, l \text{ in.}$$

$$A_s = \frac{W}{25{\cdot}800} \text{ sq. in.}$$

*B. Continuous Beam.*

The following formulæ are obtained :—

$$b = \frac{w}{325} \text{ in.}$$

$$d = 1{\cdot}84\, l \text{ in.}$$

$$A_s = \frac{W}{25{\cdot}800} \text{ sq. in.}$$

### CONDITION FOR NO SHEAR REINFORCEMENT IN A SLAB.

**In the Second Report of the R.I.B.A. it is stated :—" It is not generally necessary to provide shear reinforcement in slabs." This is quite true, but the application of the above formulæ makes the condition for no shear reinforcement very definite and remarkably simple.**

*Freely Supported Slab.*

Considering a 12-in. breadth of a slab, we have for no shear reinforcement

$$b = \frac{w}{175} \text{ in.}$$

or since $b = 12$ in.

$$w = 12 \times 175 \text{ lb.}$$
$$= 2{,}100 \text{ lb.}$$

That is to say that, irrespective of the span or depth of the slab, no shear reinforcement will be required if the load per sq. ft. of the slab does not exceed 2,100 lb.

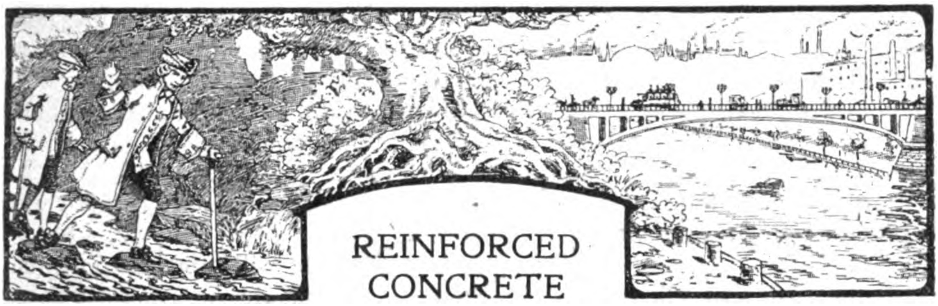
*Continuous Slab.*

Since $b = \frac{w}{117}$

Weight per sq. ft. on slab $= 12 \times 117 = 1{,}400$ lb.

Therefore, for a continuous slab, no shear reinforcement will be required if the load per sq. ft. on the slab does not exceed 1,400 lb.

The conditions thus obtained are, of course, practically equivalent to saying that shear reinforcement will never be required in a slab ; but a statement of the exact condition is interesting and perhaps surprising.



# REINFORCED CONCRETE SEA WALLS ON A TREACHEROUS CLAY FOUNDATION.

By PROF. E. R. MATTHEWS, Assoc.M.Inst.C.E., F.R.S.E. (University of London).

THE author has had occasion to design many types of sea walls and sea embankments during the past few years, and on various parts of our coasts, but, speaking generally, he has not recommended the use of reinforced concrete in their construction, except in *parts* of the structures, such as reinforced concrete piles, decking, and cantilevers ; he describes, however, in this brief article a sea wall to be built throughout of this material which he has recently designed for an East Coast local authority. He has recommended this type of structure chiefly because the natural foundation upon which the wall will be erected is London clay, and this is one of the most treacherous foundations to be found. The sea wall will be three-quarters of a mile in length, and will not only have to prevent erosion, and be strong enough to resist fairly severe wave action, but it will also have to act as a surcharged retaining wall, holding up the foot of a sliding cliff, which is full of water. The base of the wall will be widened out, as shown in *Fig.* 1, so as to distribute the weight over a large area. Numerous groynes (timber and mass-concrete) will be erected in front of this sea wall, and slipways from it will lead to the foreshore ; these will also be of reinforced concrete.

The aggregate for the concrete will be shingle, to pass through a 1 in. ring. The sand used will be sea sand, and the cement will have to pass the tests set out in the British Standard Cement Specification. By adopting this type of wall there is a small saving in cost—probably 5 to 8 per cent. A brief description of the wall is as follows :—

It consists of a reinforced concrete box, with reinforced concrete slabs forming the four sides, each of these being supported by reinforced concrete beams or ribs. The slabs are 6 in. in thickness, the size of the beams (or ribs) is 16 in. by 10 in., and every 24 ft. apart cross-walls 12 in. thick, in plain concrete, are to be inserted. The toe of the wall is well down into the clay ; the drainage at the back of the wall will be arranged as shown in *Fig.* 1, and the height of the wall above H.W.O.S.T. is 10 ft. ; there will be a projecting coping, and slab promenade 8 ft. wide, with a reinforced concrete seat. The erection of such a wall is quite an easy matter.

The author does not recommend that the structure should be any lighter than he has shown, as the force of impact of a wave is so difficult to calculate.

The reinforcement required in the walls and beams is calculated in the same manner as for floor slabs and beams, except that in the slab forming the sloping face of the wall a larger amount of reinforcement is necessary (owing to wave action) than in the slabs forming the other three sides of the box. It must also be borne in mind that the vertical wall is acting as a retaining wall. The resultant thrust falls well within the middle-third of the base.

A "plastic" mixture will be used, and the box structure will be filled with earth, well rammed, or with sand and shingle.

The structure has been designed so that the slabs will support a load (not including their own weight) of 300 lb. per sq. ft., and the ribs or beams are placed 8 ft. apart. The slab forming the sloping face should be doubly reinforced as shown in *Fig.* 3, and, wherever the slab passes over the support (rib), as the stresses are reversed at that point, top reinforcement will be inserted.

The reinforcement required in, say, the foundation slab is as follows :—

Span 8 ft. by 14 ft., to carry an external load of 300 lb. per sq. ft., not including weight of slab.

Using shingle concrete, and allowing for

$$c = 600$$
$$t = 16{,}000$$
$$\text{and } m = 15.$$

Taking the breadth first—

$$M = \frac{WLf}{8}$$

$$f = \frac{0{\cdot}05\,B + 0{\cdot}45\,L}{B} = \frac{0{\cdot}05 \times 8 + 0{\cdot}45 \times 14}{8} = 0{\cdot}837$$

$W$ = the total load, including the weight of slab.

If we take a 12 in. strip across the breadth, and assume the full depth of slab is 6 in., $W$ will be

$$\left(300 + 150 \times \frac{6}{12}\right) 8 = 1{,}800 \text{ lb.}$$

Then $$M = \frac{1{,}800 \times 8 \times 14 \times 0{\cdot}837}{8} = 21{,}099 \text{ lb.}$$

For the economic section, we may use the equations as for beams, where

$$d = \sqrt{\frac{M}{95b}} = \sqrt{\frac{21{,}099}{14 \times 95}} = \sqrt{15{\cdot}9} = 4 \text{ in.}$$

This is the effective thickness to the centre of the reinforcement. 1½ in. should be added to this, making a total thickness of 6 in.

Area of steel required = $p\,b\,d$, and $p$ for these stresses = 0·00675.

Therefore, $a = 0{\cdot}00675 \times 14 \times 4 = {\cdot}378$ sq. in., say circular bars ½ in. dia., placed 6 in. apart.

In addition to this amount of reinforcement longitudinal reinforcement will be necessary ; taking a 12 in. strip, $W = 225 \times 14$ ft. $= 3{,}150$ lb.

$$M = \frac{W\,L\,r}{8} = \frac{3{,}150 \times 14 \times 12 \times 0{\cdot}275}{8} = 18{,}911 \text{ lb.}$$

$r$ = a coefficient 0·275.

The depth of the reinforcement to give the same stresses will be :—

$$\sqrt{\frac{M}{95b}}=\sqrt{\frac{18,911}{14\times 95}}=\sqrt{14\cdot 2}=3\cdot 77\text{ in.}$$

$$a=p\,b\,d=0\cdot 00675\times 14\times 3\cdot 77=0\cdot 356\text{ sq. in.}$$

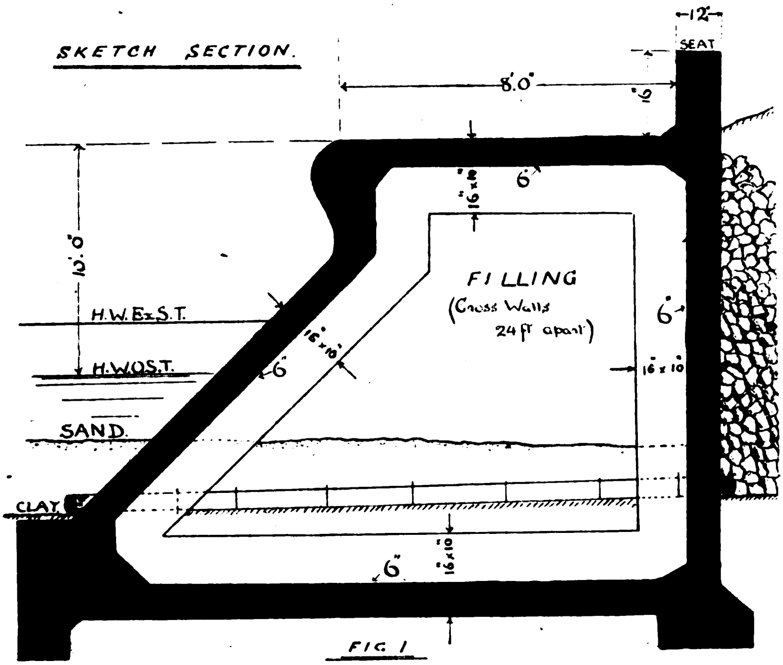


FIG 1

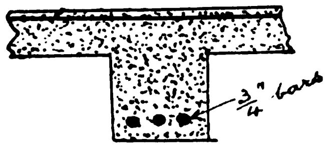


FIG. 2.

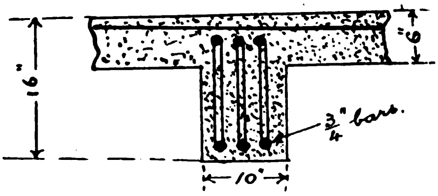


FIG. 3.

Longitudinal reinforcement, say ½ in. bars spaced at 6 in. centres (see *Fig.* 2).

The vertical wall and promenade slab will be reinforced in like manner, but the sloping face of the sea wall will have ⅝ in. bars, longitudinal and transverse, on the inside, with transverse bars (say ¾ in.) within 1 in. of the outer face of the wall.

The sloping-faced slab will be supported by beams which have on the top and bottom three ¾ in. bars (see *Fig.* 3), although ½ in. bars are sufficient.

The maximum load on the clay foundation is 1 ton per sq. ft., and on the reinforced concrete foundation slab (weight of filling, etc.) a little less than 1 ton per sq. ft.

The ribs or beams throughout are 16 in. in depth, and 10 in. in width; this depth includes the width of the slab (see *Fig.* 3).

It will be necessary, as already stated, to reinforce the sloping wall with double reinforcement, as the pressure of the earth or shingle filling on the inside face of the wall will cause tension on the outside face of the slab, as well as the wave pressure on the outside of the slab causing tension on the inside face.

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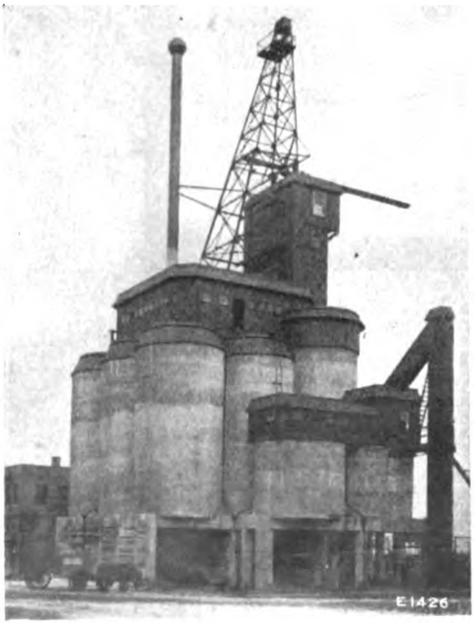
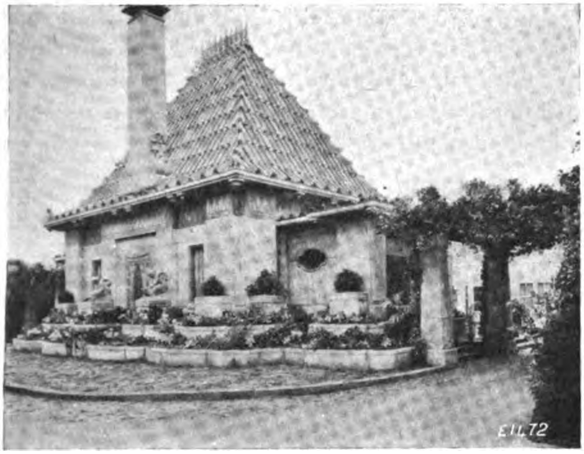
## MEMORANDUM.

**A Concrete Coal Cylinder Plant.**—The accompanying illustration shows a novel and interesting reinforced concrete coal cylinder plant, which was built with moving forms in New York City at the foot of East Nineteenth Street.



This plant includes, besides the concrete coal pockets, the coal-hoisting machinery, headhouse and appurtenances and the office-scale house. The concrete coal pockets are formed by nine cylinders, each of 18 ft. in inside diameter, on a reinforced concrete platform of columns, girders, beams and slabs. There are two additional concrete cylinders of the same diameter and similarly supported, located alongside the forms intended as a rescreening plant. The supporting structure consists of four rows of reinforced concrete columns 18 ft. apart, each row consisting of from seven to nine columns. These support a platform of beam and slab construction, intended to support the cylinder pocket, at such an elevation as to give 12 ft. clear headroom above the street level. Between each of the four rows of columns there is a driveway. The sea wall affords a foundation for the row of columns nearest the river, and for each of the other three rows a foundation was provided consisting of wooden piles driven to refusal, cut off below water level and each row capped with a concrete wall and footing extending to within 2 ft. of the yard level and reinforced with steel near the top. After the completion of the platform, circular forms were erected for all nine cylinders, to a height of 4 ft., the plan being to cast the cylinders in a continuous operation by moving the forms up steadily as the concrete was poured.

Concrete was poured continuously in all cylinders during construction; the band reinforcement was placed at proper intervals as the concrete rose and was secured to the vertical rods by wires. While some workmen poured concrete, others turned the jacks and raised the forms. Great care was taken to give each jack the same turn and to keep all forms moving together and plumb.

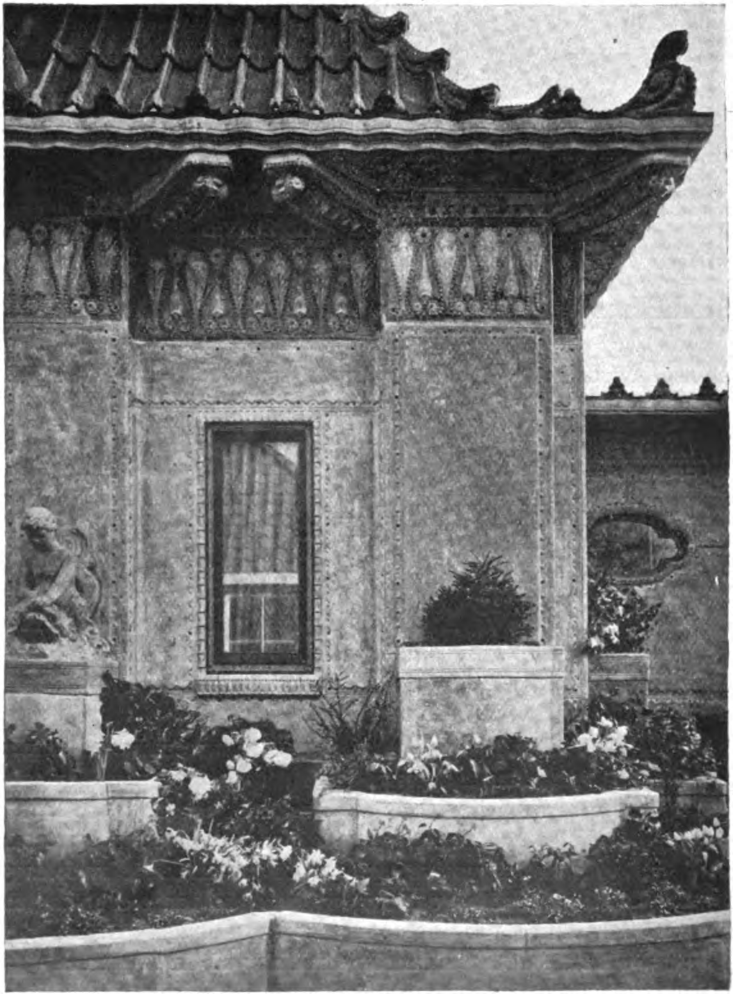


# METALLISED-CEMENT DECORATION.

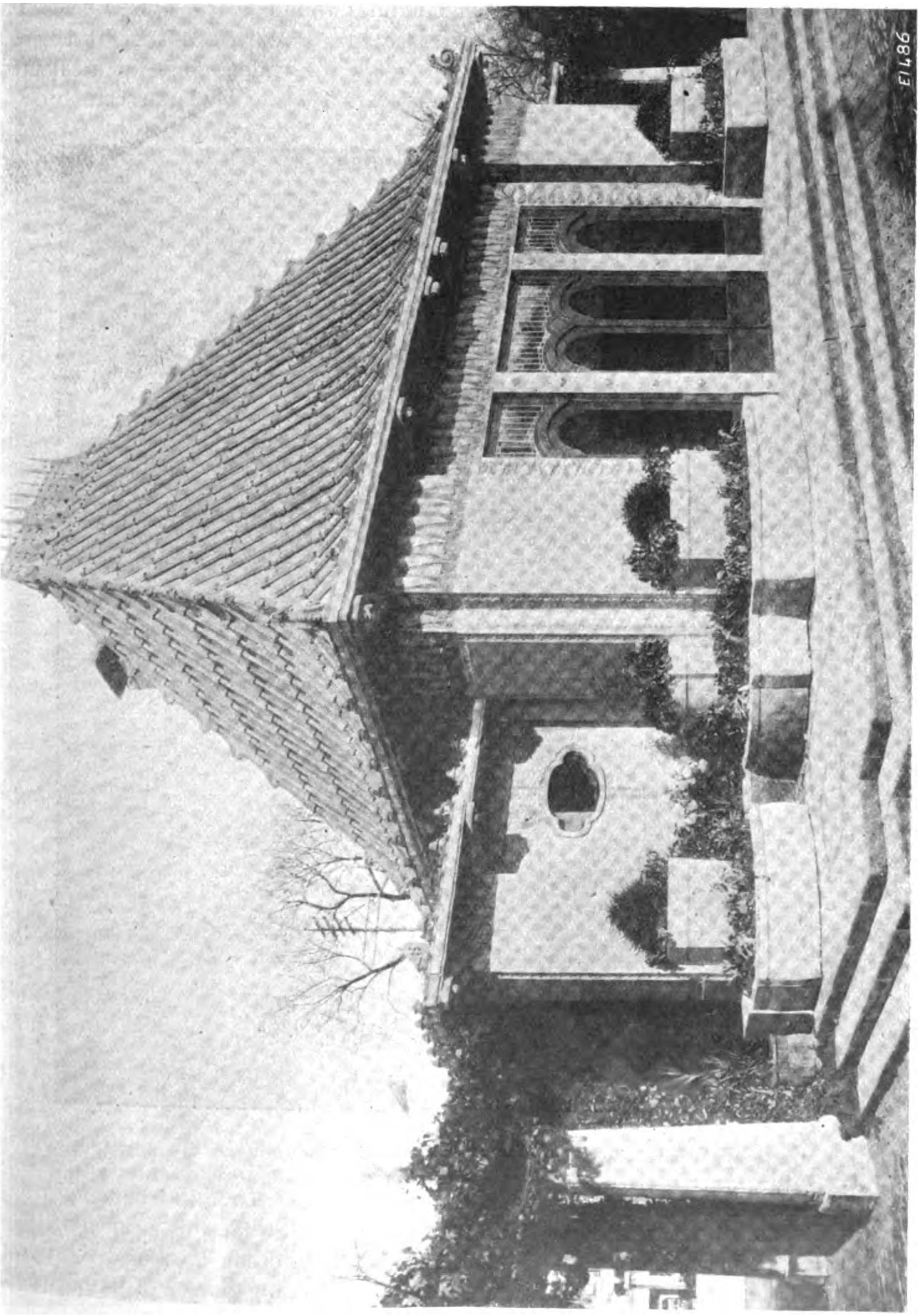
In our last issue we briefly referred to a process for the colouring and decoration of cementitious materials by metallisation, and we are now able to give some illustrations of work treated with this process. The views are of a sample structure erected in Holland some three and a half years ago, which has withstood the weather during that period without, it is stated, showing any signs of deterioration or loss of colour. Methods of colouring concrete, such as by the use of different kinds of aggregate, or by the mixing of oxide of iron, copper or chromium, or other colouring material with the cement, have been tried to a limited extent, more especially in the United States, but without any marked degree of success. If, however, this discovery fulfils all that is claimed for it, it would appear that a new era in the decorative treatment of concrete and cement surfaces is about to be opened up.

The process is the invention of Messrs. Sanders, two engineers connected with the Dutch concrete building industry. The solution of metallic salts, which imparts the colouring, is applied with a hair brush and penetrates to an appreciable depth into the surface of the material. In addition to the colouring, the treatment is stated to increase the compressive strength of the material by from 50 to 100 per cent., and also to render it impervious to rain and damp. Owing to the fact that it penetrates the surface and is not merely an applied coating, it cannot be effaced by wear and can be kept clean by scrubbing or other means. At present a range of about 35 colours are being used, and, if desired, the solution can be prepared to produce any combination of colours or mottled effects. The application of the solution leaves the coloured surface dull, but this can be polished to any degree of brilliancy by treatment with wax, French polish, or any other common method. According to the effect desired, the cost, including labour, works out at from 2s. 6d. to 15s. per superficial yard. Providing the aggregate used is sufficiently small to produce a fairly smooth surface the interiors of concrete walls can be treated direct with this process, thus rendering plaster and distemper unnecessary.

The illustration of an interior (see *Frontispiece*) gives an idea of what can be done in this direction, and the result is very effective. The walls are covered with plain and moulded cement asbestos-sheeting, which can be produced to resemble either a plain distemper finish or rare marbles and other stones. Colouring can also be produced to resemble copper, bronze, silver, old wood, etc., and some small ornaments which we recently inspected bore out the resemblance to a remarkable degree. Statues and garden ornaments made of concrete and coloured to a bronze, marble, or pottery appearance were very effective, and possessed the additional advantage that they would not be discoloured by the weather.

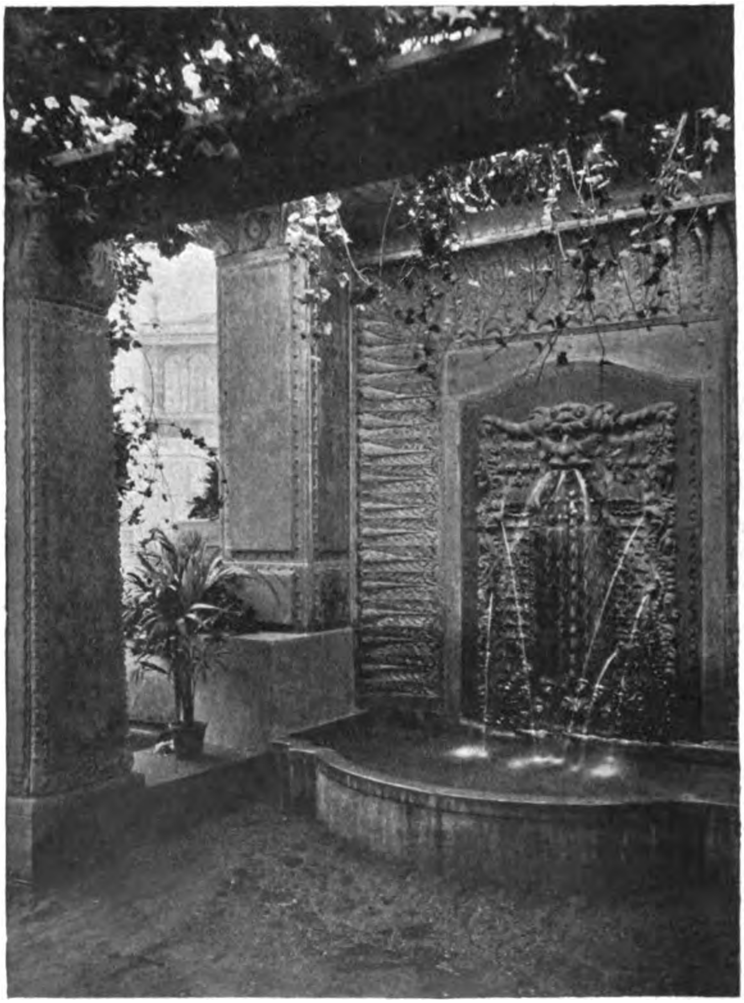


METALLISED-CEMENT DECORATION.



METALLISED-CEMENT DECORATION.

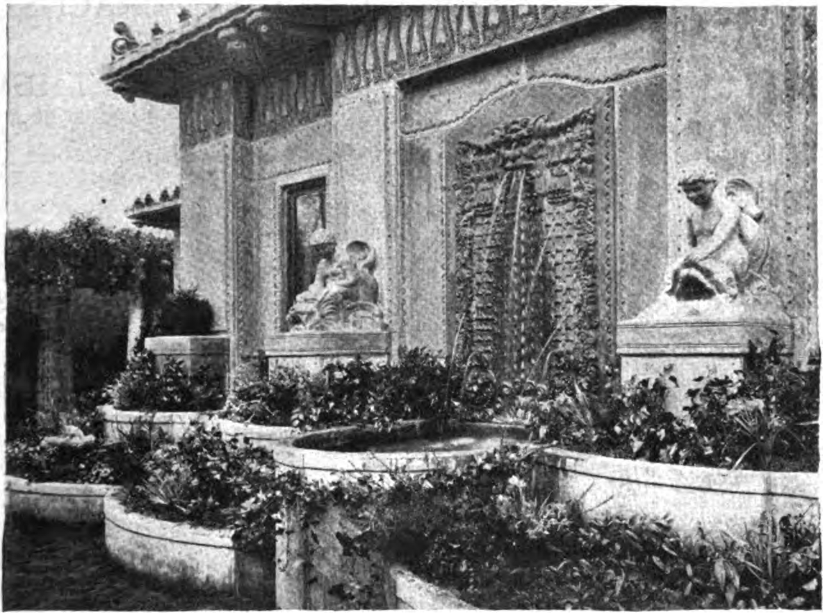
We understand that at the works at Amsterdam model dwellings, frescoes, temples, and samples of many other buildings and decorations, both ancient and modern, have been manufactured and treated. Fireplaces of several designs are also being made. These are of concrete made in wooden moulds and coloured to resemble old wood or marble. There appears to be a very large scope indeed for an invention such as this in the direction of the economical building methods which are so much needed at the present time. So far this economy has been secured by the elimination of much that is purely ornamental or decorative and does not fulfil any utilitarian purpose, but if the appearance of the new houses can be made brighter and more pleasing, both outside and inside, at the same cost



METALLISED-CEMENT DECORATION.

as at present the objections to concrete, which are mainly on account of its appearance, should be swept away.

The invention has been patented in this and most other European and overseas countries, and a syndicate is now being formed to exploit the process in Great Britain. Orders, however, can be carried out at the works in Holland, and inquiries should be addressed to Mr. Francis F. Proctor, 7, Vondel Straat, Amsterdam.



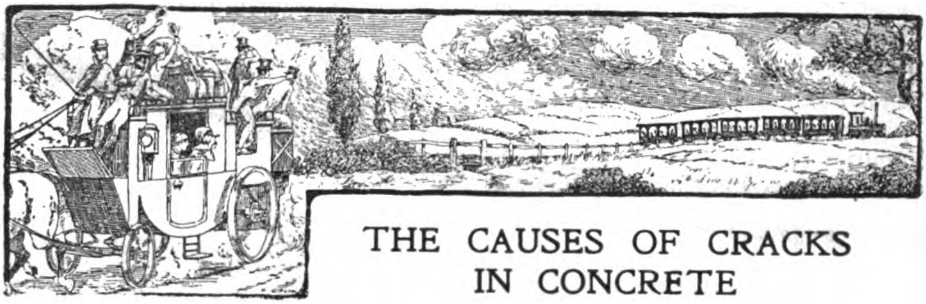
Metallised-Cement Decoration.

## MEMORANDA.

**Standard Specifications for Concrete and Reinforced Concrete.**—A brief memorandum has been issued by Mr. Duff A. Abrams, secretary of the Structural Materials Research Laboratory, Chicago, concerning the work of the new Joint Committee on Standard Specifications for Concrete and Reinforced Concrete which has been organised in America. The Committee consists of five representatives from each of the following organisations: American Society of Civil Engineers; American Society for Testing Materials; American Railway Engineering Association; Portland Cement Association; American Concrete Institute.

The purpose of the Committee is to make a thorough study of all available data on the subject of concrete, concrete materials and reinforced concrete and to incorporate the most modern information and experience into a general specification which may serve as a pattern for detailed specifications covering specific types of concrete construction.

The following committees, consisting of five to seven members each, have been organised:—(1) Concrete Materials; (2) Metal Reinforcing; (3) Proportioning and Mixing; (4) Forms and Placing; (5) Design; (6) Details of Construction; (7) Waterproofing and Protective Treatment; (8) Surface Finish; (9) Form of Specification.



# THE CAUSES OF CRACKS IN CONCRETE PAVEMENTS AND HOW TO PREVENT THEM.

By **A. E. WYNN**, A.M.Am.Soc.C.E.
*(Formerly Engineer of Bridges, Toronto-Hamilton Highway Commission, Canada.)*

CRACKS in concrete pavements can be divided into two main divisions:—first, those resulting from the concrete itself; secondly, those due to the subgrade.

## SUBGRADE.

The most important cracks are those due to the subgrade. The causes are improper rolling of the subgrade, difference in the material composing the subgrade, and chief of all inefficient drainage.

*Rolling.*—The subgrade should be rolled thoroughly to a uniform hardness; insufficient rolling will leave some spots softer than others and the pavement will give way and crack at these points under heavy loads. Over culverts and fills especially great care should be taken in rolling and no concrete should be laid until all settlement has ceased. A 10-ton roller is best suited for the purpose.

*Difference in the material* composing the subgrade cannot be avoided as the road will pass over different strata.

The weak points will be at the junctions of the different materials and these should be carefully reinforced with steel. Wire fabric or heavy wire fencing is best suited to the purpose; it should be placed about 1½ in. from the bottom of the concrete and it is also advisable to place a layer near the top of the concrete. Soft spots in the subgrade should be filled in with a harder material, well rolled and reinforced.

*Drainage* is probably the most important point in concrete road construction and more cracks are due to poor drainage than to any other cause. The problem is the same as with any other type of construction. The worst places will be in cuts, and if there is any doubt as to the efficiency of the drainage methods adopted the concrete should be reinforced both top and bottom. Reinforcement should be placed in the top because if there is any water in the subgrade to freeze the pressure will be upwards.

It must always be kept in mind that, unlike other types of pavement, the subgrade is the foundation of the road and carelessness in its preparation will result in a poor concrete surface. Much criticism has been directed against concrete roads because of the prevalence of cracks, which have been due, not to the concrete, but to the subgrade.

## CRACKS IN THE CONCRETE.

Cracks resulting from the concrete itself are due to the following causes: changes in temperature, too wet a mixture of concrete, absorption of moisture, insufficient curing, faulty construction of joints, poor material used for the aggregate and improper proportioning of the constituents.

In the Northern States and Canada the range in temperature is very high, being about 140° F., so that conditions in England should be much more favourable where the range is only about half as much.

To prevent too rapid expansion and contraction during the period of setting the concrete should be protected in very hot weather from the sun's rays by tarpaulins.

Expansion due to climatic changes is allowed for by the expansion joints, which should be about 35 ft. apart and ½ in. wide.

A good filler is necessary, and when this is worn out care must be taken in thoroughly cleaning out the joint before filling with tar.

*Temperature Changes.*—Cracks due to temperature changes are not really very important as they are only hair cracks. Reinforcing the pavement will localise the cracks and prevent them spreading, but it seems to be an unnecessary refinement. Some engineers advocate using no joints, but in that case the pavement should be reinforced throughout in order to take up the stress. This method has not yet been given sufficient trial to warrant its adoption extensively.

Too wet a mixture of concrete will crack more easily from temperature causes and under the trowelling too much water will be brought to the surface. In the water will be fine particles of cement which will lie on the surface as dust after the water has dried out; also with too much water small holes are likely to occur on the surface.

*Water.*—The amount of water required should be accurately determined in the laboratory as different aggregates will require different amounts of water to give the correct consistency.

The water should then be gauged by a meter fixed on the mixer. This correct gauging of water is a point that is usually not given any particular attention, being left to the man on the mixer to decide, and the tendency is to get an excess of water as the concrete will work more easily.

Just sufficient water should be used to enable the concrete to flow and to come to the surface only under trowelling. If two consecutive batches are of different consistency there will be a weak plane between them.

*Absorption of moisture* by the concrete can be controlled by scientifically proportioning the constituents so that the voids will be filled by the mortar. The denser the concrete the less will be the amount of water absorbed. Hydrated lime to the amount of 10 per cent. of the cement will aid in giving a denser concrete, and is being used extensively.

The concrete pavement should be allowed to dry out slowly. Too rapid drying out will cause cracks. After concreting the pavement should be covered with earth, sand or shavings kept soaked with water for at least ten days, or clay can be placed along the edges and the interior flooded with water. No traffic should be allowed on the road under four weeks.

*Joints.*—Poor construction of joints will cause cracks and upheaving. The joints should be true lines and vertical; if they are not vertical one side of the pavement will tend to mount over the other.

*Materials.*—Poor material used for the aggregate and improper proportioning will give a weak concrete that may crack under heavy loads. Too much stress cannot be laid to the laboratory side of concrete road construction. Good materials are essential and they should be so mixed that the resulting concrete will have maximum strength and density; this can only be decided in a laboratory.

It may not be possible at present to prevent cracks entirely, but with careful attention paid to the above mentioned details there should be few, if any.

However, if they do occur, they have no serious effect on the road, and can be easily and cheaply repaired.

People are apt to attach too much importance to cracks and usually exaggerate their size; many of the so-called serious cracks are difficult to find unless you know where to look for them.

## MEMORANDA.

**Concrete Work in Winter.**—The difficulties attending concrete construction in cold weather are now rapidly being overcome. This is specially noticeable in American practice, and, in fact, it may be said that in that country the weather is never allowed to interfere with any work which is urgently required; moreover, perfectly good and sound construction is produced under the most severe conditions. In addition to the usual methods of heating the aggregate with steam-pipes before mixing, an interesting innovation was introduced in the construction of a large reinforced concrete girder at a new theatre at Toronto. The girder has a clear span of 51 ft., is 13 ft. deep and 2 ft. 2 in. wide. The pouring took place in December last, and to protect the concrete from frost whilst setting, two 1 in. steampipes were run from end to end, one 3 ft. and the other 8 ft. from the bottom of the girder. After the girder had set and the pipes had fulfilled their function they were cut at the ends and left in the girder, forming an additional reinforcement.

**Dublin.**—Improvements have been, and are still being, made on the back road to the Port of Dublin. These improvements include among others a new concrete footpath extending over nearly two miles, from Annesley Bridge Fairview, eastward along the Wharf road.

**Hampton Court.**—A long concrete platform is being constructed below the rails of the Water Gallery, outside Hampton Court Palace, this being rendered necessary through the subsidence of the river embankment. Originally the Water Gallery, situated opposite the colony of houseboats, was the site of the dock for the Royal Barge.

**Reinforced Concrete for a Brew House.**—Reinforced concrete has been used fairly extensively in connection with the new brew house recently erected at Fürth, Bavaria. The building itself is of reinforced concrete and the same material has been used for three large water tanks of 86,000 gals. capacity, as well as for the four malt storage bins having a total capacity of 1,400 cwt.

**The Institution of Civil Engineers, " James Forrest " Lecture.**—The 26th " James Forrest " Lecture will be delivered at the above institution on Tuesday, April 20th, at 5.30 p.m., by Sir Dugald Clerk, K.B.E., F.R.S., M.Inst.C.E., the subject being " Fuel Conservation in the United Kingdom."

# THE STORY OF A CONCRETE ROAD TOLD IN PICTURES.

*In our last issue we referred to the cinematograph for educational purposes in the engineering field, and gave a brief account of a demonstration we had been permitted to witness at the offices of the Allied Machinery Company, showing the latest American practice in road-making. By the courtesy of the above Company we are able to reproduce below the series of pictures showing the making of a concrete road in the United States. These pictures were also shown at a recent meeting of the Concrete Institute*—ED.

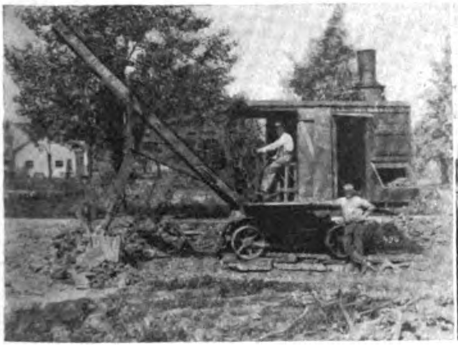


Fig. 1. A small type of "Thew" Shovel preparing the subgrade. Note the horizontal crowd mechanism which enables the shovel to form its own grading.

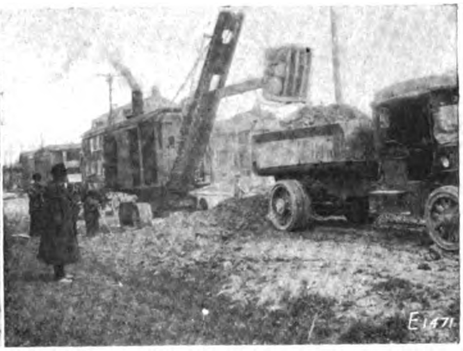


Fig. 2. Type of "Thew" Shovel with ship-a-shaft mechanism loading into the lorry.

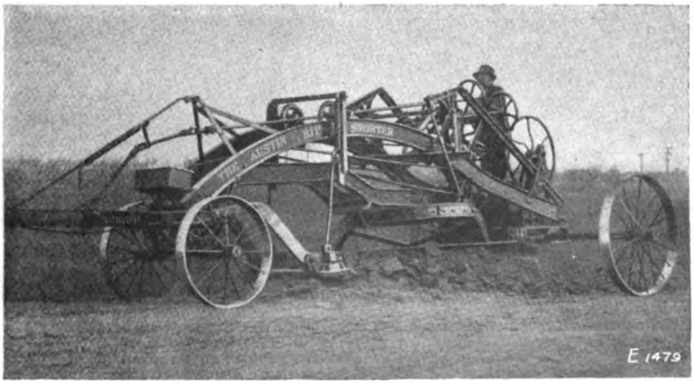


Fig. 3. Grip-Snorter scarifying and grading macadam road prior to concreting.

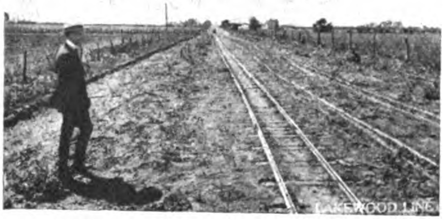


Fig. 4. A typical type of road to be concreted, showing the light gauge railway for conveying the aggregate to the mixer.

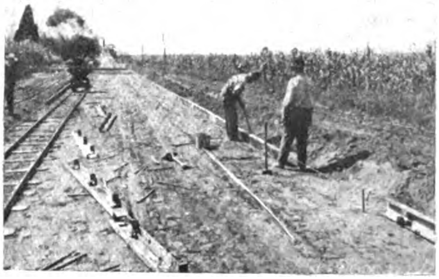


Fig. 5. Road prepared and pressed steel side forms being laid.

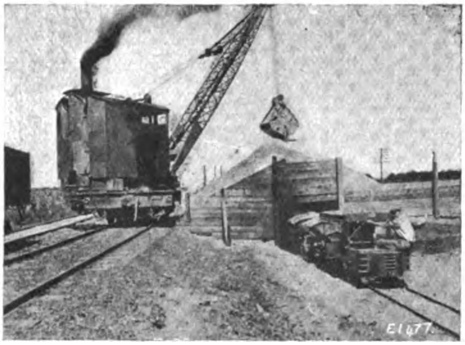


Fig. 6. Handling the material at depot ; unloading gravel from railway trucks over storage bins, under which is a tunnel where the trains can be automatically charged by tunnel traps.

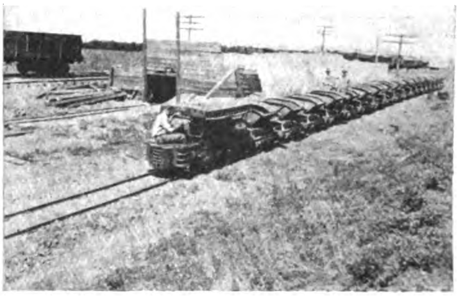


Fig. 7. Loading of sand.

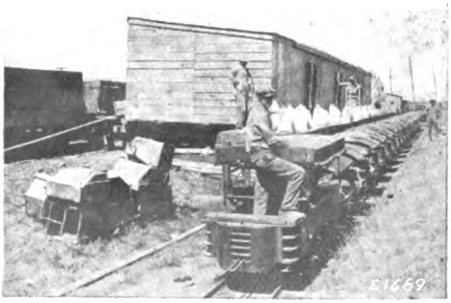


Fig. 8. Loading cement at cement depot.

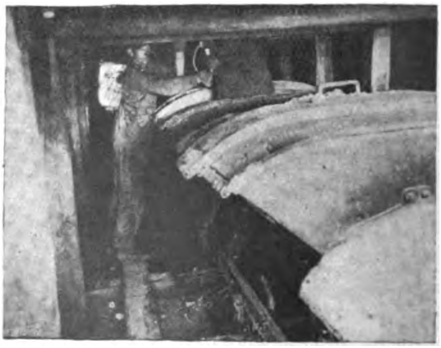


Fig. 9. View in the tunnel, showing tunnel traps. Note the three partitions in trucks for gravel, sand and the middle section for cement, which is fitted with a cover to keep cement dry. This contains one complete batch for the mixer.

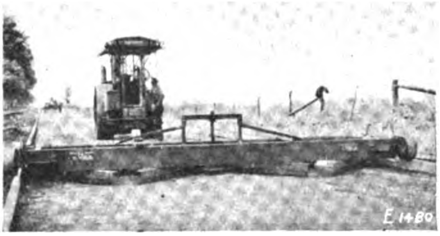


Fig. 10. Grader assuring that the exact depth of concrete is obtained.

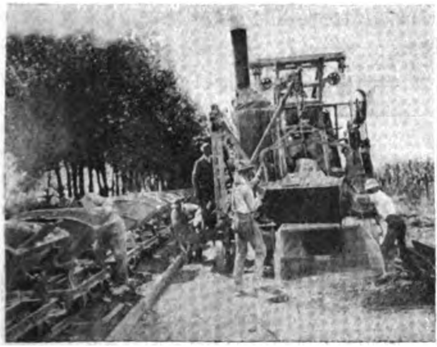


Fig. 11. Concrete Mixer operated by steam engine and boiler and propelled by its own power. A power loader is attached which automatically picks up a truck containing the correct mixture for a complete batch and automatically swings out to the receiving hopper. This loader is operated by the receiving hopper, the weight of which going down raises up the charged truck, which is returned empty, and replaced in position in the train when the receiving hopper is lifted up, shooting the material into the mixer.

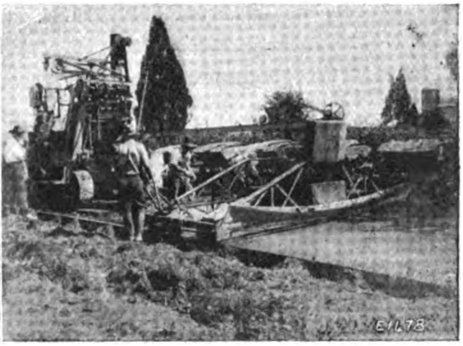


Fig. 12. View of the other end of the mixer; the boom, which swings the full width of the road, carries a 14 cu. ft. bucket, which, after being charged from the mixer, is run down the boom and automatically dumps in position where the men require the concrete; thus all man-handling is avoided. When this returns to the mixer the bottom of the bucket is automatically closed ready for a fresh charge.

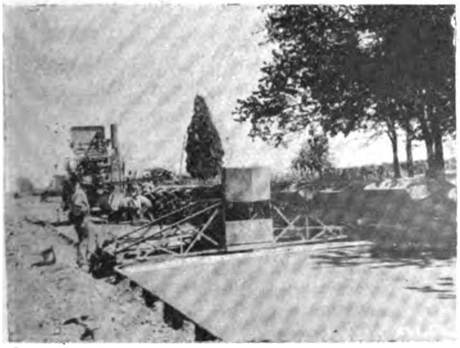


Fig. 13. After the concrete is laid a finishing machine, running on the steel side forms, works over the concrete, tamping it and giving the concrete right camber. This machine, being operated by a small petrol motor, agitates the concrete, working up the air voids, making it more dense and, therefore, giving it considerably more strength. Note the finishing belt, which gives a perfectly even finished surface.

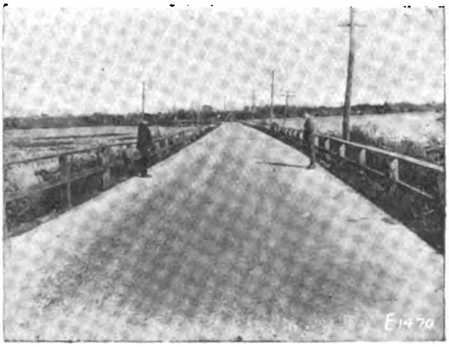


Fig. 14. The finished concrete road.

# THE BEHAVIOUR OF REINFORCED CONCRETE COLUMNS UNDER FIRE TEST.

## Part II.

By **WALTER A. HULL**, U.S. Bureau of Standards, Pittsburgh, Pa.

*The following is an abstract of an article which we reproduce, with illustrations, by courtesy of the "American Architect," and deals with the second series of tests undertaken by the United States Bureau of Standards to ascertain the behaviour of concrete columns under fire test.—ED.*

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THE results obtained from the first series of tests conducted by the United States Bureau of Standards seemed to indicate that reinforced concrete columns in which gravel was used as the coarse aggregate were unreliable under the action of fire, and serious failures might result in buildings constructed of concrete using this type of aggregate. On the other hand, gravel is very often an economic necessity in reinforced concrete construction in certain localities. For this reason the later investigations were conducted with a view to making gravel concrete columns more fire resistant. The scope of the tests was also extended to include test specimens composed of additional aggregates, both in round columns with vertical and spiral reinforcements and in vertically reinforced square columns. The previous tests demonstrated clearly that the various aggregates show their fire-resisting characteristics most strongly in columns of these two types.

With the exception of columns cast in forms made from gypsum, all the columns were made 18 in. in diameter if round, or 16 by 16 in. if square, and 8 ft. 9 in. long. As in the columns previously reported, one proportion, 1 : 2 : 4, has been maintained throughout. Concrete was mixed and placed by hand. The consistency was somewhat less fluid than that ordinarily obtained with machine mixing, being that resulting from the use of a weight of water approximately 8 per cent. of that of the total weight of the dry batch. It might properly be called a quaking consistency. When first mixed it would stand in a somewhat flattened mound without spreading out over the floor. The concrete required considerable poling in placing. There was very little tendency for water to separate and rise to the top; when the form was filled to overflowing the overflow was mortar, for the most part, rather than separated water. Columns, whether fire tested or not, did not show a tendency to give top failures.

In all tests, the working load of the column was kept on the column during the fire test. In most of the tests the load has been increased at the finish of the fire test, up to the ultimate strength of the column or to the capacity of the testing apparatus. If the column withstands the 600,000 lb. load, it is permitted to cool, transferred to a 10,000,000 lb. capacity testing machine and tested in the larger machine until failure occurs.

Data in condensed form, giving results of tests of round columns from additional aggregates are given in Table I. In considering these results, in connection with the results of tests previously published, it should be taken into account that most of these newer tests were made at ages slightly greater than four months, whereas the earlier ones were made on columns considerably older than these, most of them older than six months.

Columns 42 and 43 were of gravel, made up almost entirely of smooth nearly white pebbles, fairly well graded as to size. These columns behaved in a manner similar to that of the columns of the same type from Pittsburgh gravel, already reported. The protective concrete commenced spalling early in the burn. In the case of column No. 42 a portion of the reinforcement was exposed within the first thirty minutes of firing, and in column No. 43 this occurred within forty-two minutes. In both cases the larger part of the protective concrete had broken up and fallen off before the end of the first hour of firing. The spalling, while similar in nature to that of the Pittsburgh gravel columns, occurred somewhat earlier in the test in these pure quartz gravel columns. Rapid expansion was indicated by the fact that it was necessary to operate the valve on the test pump, letting oil out of the jack, to prevent the load on the column from increasing. As in the earlier tests, temperatures in steel and in load-bearing concrete increased rapidly after the protective concrete began to fall off.

The so-called Cow Bay gravel was made up of a mixture of pebbles, mainly of three kinds. There was a large proportion of large pebbles of coarse-grained granite and a considerable proportion of large pebbles of gneiss. Most of the other pebbles were of quartz. In the fire tests the columns from this gravel showed the same general tendency as those from pure quartz gravel, but the spalling did not start as early in the test nor proceed as rapidly. In columns 46 and 47 it was over an hour and thirty minutes before the load-bearing portion of the column was observed to be exposed to an important extent. In all the columns from the so-called Cow Bay gravel granite pebbles were shattered in the outer portion of the columns. Gneiss pebbles were reduced to loose-grained masses, so utterly devoid of bond that it was difficult to recover the remains of a pebble in its original form. The individual quartz pebbles in this aggregate and also in the pure quartz gravel showed only a comparatively slight tendency to disintegrate or disrupt in the fire test.

In the fire tests of the columns made with blast furnace slag aggregate a lively snapping was heard in the early part of the test, principally within the time between the first fifteen and the first thirty minutes of firing. The sounds resembled the popping of corn and appeared to be caused by miniature explosions just beneath the surface of the concrete. A few vertical cracks, very fine and apparently of no importance, appeared in the course of the tests. There was no spalling.

Observations during the test on the behaviour of columns with trap rock showed no spalling and no cracking of importance.

In Table II. the results of tests on square columns of additional aggregates is given. Spalling was noted in No. 44 after thirty-three minutes of firing and in No. 45 after forty-five minutes. In both cases the spalling at the corners continued rather rapidly, until, after the end of the second hour, most of the concrete outside the vertical rods had broken loose and fallen away. In the latter part of the burn cracks appeared in the sides of the columns. These columns, like those of the same type from Pittsburgh gravel, were very much shattered after failure.

In the square columns from blast furnace slag and from trap rock no spalling and practically no cracking took place in the fire test. In the case of the columns from blast furnace slag, the same miniature explosions in the concrete next to the surface were noted as in the tests of the round columns from slag concrete. Evidence of these disturbances was left in the form of shallow pits over the surface of the concrete. The general observations on the behaviour of slag and trap rock columns during fire test have been similar to those on columns from limestone concrete reported last year, namely, no spalling and no cracking of importance.

E

It was observed in the tests of a number of the columns that were tested at an age of approximately four months that water appeared to be issuing from the surface of the column at some point in the upper half of the column after about thirty minutes of firing. The appearance was that of a small stream of water bubbling and trickling out of the column and a part of it trickling down over the surface for several inches. This continued for a few minutes and then stopped. No such observations have been made in the tests of older columns.

**TABLE I**

18-in. cylindrical columns.
Reinforcement: 2 per cent vertical, 8 round rods, ¾ in. diam.
1 per cent spiral, $\frac{5}{16}$ in. diam., 2 in. pitch, 2 spacers.
Effective area concrete, 168.7 sq. in.
Area vertical steel, 3.53 sq. in.
Effective area column, 172 sq. in.
Working load, 141,500 lb.

| | Column Number | Maximum Load Lb. | | Maximum Stress Lb. per Sq. In. | Maximum Temperature at End of 4-Hour Fire Test, Deg. C. | | |
|---|---|---|---|---|---|---|---|
| | | Without Fire Test | At End of 4-Hour Fire Test | | In Steel | Midway | At Center |
| Pure quartz gravel | 42 | .... | * | .... | 990 | ... | ... |
| Pure quartz gravel | 43 | .... | * | .... | 990 | 350 | 150 |
| Cow Bay gravel.. | 46 | .... | * | .... | 985 | 275 | 100 |
| Cow Bay gravel . | 47 | .... | * | .... | 1000 | 250 | 105 |
| Blast furnace slag. | 48 | .. | 465,000 | 2700 | 480 | 85 | 85 |
| Blast furnace slag. | 49 | 839,000 | .... | 4870 | ... | ... | ... |
| Blast furnace slag. | 50 | .... | 393,000 | 2260 | 465 | 110 | 100 |
| Trap rock....... | 54 | .... | 417,000 | 2420 | 610 | 190 | 100 |
| Trap rock..... | 55 | .... | 516,000 | 3000 | 560 | 239 | 110 |
| Pittsburgh gravel | 58 | .... | 365,000 | 2120 | 620 | 140 | 100 |
| Pittsburgh gravel | 59 | .... | 525,000 | 3050 | 410 | 100 | 90 |
| Pittsburgh gravel | 60 | .... | 207,000 | 1200 | 810 | 260 | 90 |
| Pittsburgh gravel | 61 | .... | 482,000 | 2800 | 185 | 160 | 110 |
| Pittsburgh gravel | 63 | .... | 304,000 | 1770 | 590 | 185 | 90 |
| Pittsburgh gravel | 66 | .... | 222,000 | 1290 | 765 | 335 | 150 |
| Pittsburgh gravel | 65 | ... | * | .... | 440 | 220 | 100 |

*Column No. 42 failed, under working load, at end of 3 hrs. 32 min.
Column No. 43 failed, under working load, at end of 3 hrs.
Column No. 46 failed, under working load, at end of 3 hrs. 37 min.
Column No. 47 failed, under working load, at end of 3 hrs. 40 min.

Columns Nos. 58 and 59 were cast in gypsum forms of such dimensions as to give a protective coating of 1 in. concrete and 3 in. gypsum. Wire hoops over the gypsum on No. 59.

Columns Nos. 60 and 61 were cast in gypsum forms of such dimensions as to give ½ in. of concrete and 2 in. of gypsum over the steel. Anchorage for the gypsum was provided in the case of No. 61.

Column No. 63 was plastered with cement plaster, over the concrete. Concrete column was 16 in. in diam., plastered so as to make 18 in. diam.

Column No. 66 was cast in a form made by covering the spiral reinforcement with metal lath and plastering on the metal lath with cement plaster.

Column No. 65 was made the same as No. 63, except that a special plaster, containing asbestos, was used.

### PROTECTIVE COVERING OTHER THAN CONCRETE.

The tests already reported as well as the results of a number of fires in concrete buildings have shown that gravel concrete from gravel high in quartz cannot be depended on for as good resistance to fire as concretes from a number of other aggregates. Three distinct types of gravel have made records very much alike in this series of fire tests, and since most gravels are high in quartz, whose expansion behaviour appears to be responsible for the poorer results shown by these aggregates, possible means of overcoming this handicap appear to be of importance. In previous tests it had been shown that the addition of 1 in. of cement plaster with a reinforcement or binder of light expanded metal enabled round columns of gravel concrete, with both vertical and spiral reinforcement, to withstand the four-hour fire test somewhat better than limestone concrete columns without the additional protection. Such a method of securing adequate protection would, of course, involve additional expense if followed in practice. Another possible means of safeguarding gravel concrete columns is that of placing metal binder, or reinforcement, such as very light expanded metal, in the protective concrete. This could be done by placing the expanded metal or other material in the space between the form and the reinforcement before pouring the concrete. This would tend to prevent the protective concrete from falling away in case of spalling. A series of such columns is being made up as a part of this investigation, but no test results are available at this time. Concrete of a consistency as wet as could conveniently be made by hand mixing has been used in these columns and no difficulty has been occasioned in the placing of concrete by the additional expanded metal. Results of those tests of round gravel concrete columns without spiral reinforcement, in which there was no considerable loss of protective concrete, indicate that this simple expedient can hardly be expected to put gravel concrete on a par with concrete from other aggregates, and it has seemed worth while to make a test of other possible methods of accomplishing this.

TABLE II

16-in. square columns.
Thickness of zoncrete outside the steel, 1½ in.
Reinforcement: 2 per cent vertical, 4 round rods, 1 in. diam.
Ties ¼ in. diam., 12 in. centers.
Effective area concrete, 156 sq. in.
Area steel, 3.14 sq. in.
Effective area column, 159.14 sq. in.
Working load, 92,000 lb.

| | Column Number | Maximum Load, Lb. | | Maximum Stress, Lb. per Sq. In. | Maximum Temperature at End of 4-Hour Fire Test, Deg. C. | |
|---|---|---|---|---|---|---|
| | | Without Fire Test | At End of 4-hour Fire Test | | In Steel | At Center of Column |
| Pure quartz gravel | 44 | .... | 108,000 | 680 | ... | .... |
| | 45 | .... | 138,000 | 868 | 1000 | 280 |
| | 51 | .... | 362,000 | 2278 | 90 | 100 |
| Blast furnace slag | 52 | 748,000 | .... | 4700 | ... | .... |
| | 53 | .... | 303,000 | 1905 | 770 | .... |
| Trap rock | 56 | .... | 295,000 | 1855 | 690 | .... |
| | 57 | 713,000 | .... | 4480 | ... | .... |

Another expedient that is being tried out is that of making columns with only a small thickness of concrete over the steel and applying additional protective material in the form of plaster. This is being tried out, but the cost of such columns would obviously be greater than that of columns made in the regular way. Inasmuch as the cost of forms for round columns is considerable, the possibility of doing away with the usual type of form appears to be worth considering as a means of offsetting, wholly or in part, the difference in cost between protective concrete cast with the rest of the columns and other protective material, applied in some other way. Consequently, a number of columns have been made in which the form consists of hollow tiles, much like sewer pipe without sockets, made of gypsum and set up in the form of a hollow cylinder around the steel reinforcement. Concrete is poured in such a form exactly as in the ordinary form, but the gypsum form, instead of being removed, stays in place to serve as protective covering for the column. No difficulty has been experienced in the laboratory in making columns in this way. The columns made have been cylindrical, without enlargement at the top.

Another method being tried for eliminating the usual expense of the column form is that of covering the spiral reinforcement with metal lath, with lapped joints, wired, and casting the concrete in that. Only two columns have been made in this way up to this time, but the observations indicate that there would be no serious difficulty about making columns in this way if it should prove advantageous to do so. Concrete with as wet consistency as can be made conveniently by hand mixing appears to exert no pressure of any consequence on metal lath so placed, and the quantity of mortar which works out through the metal is not a serious matter. It is likely also that the ordinary metal lath could be improved on for this purpose. Columns made in this way would, of course, have to be covered with protective material. The possible advantage is that with material of good insulating properties columns may be afforded adequate protection with less thickness and less weight of material without serious increase in cost.

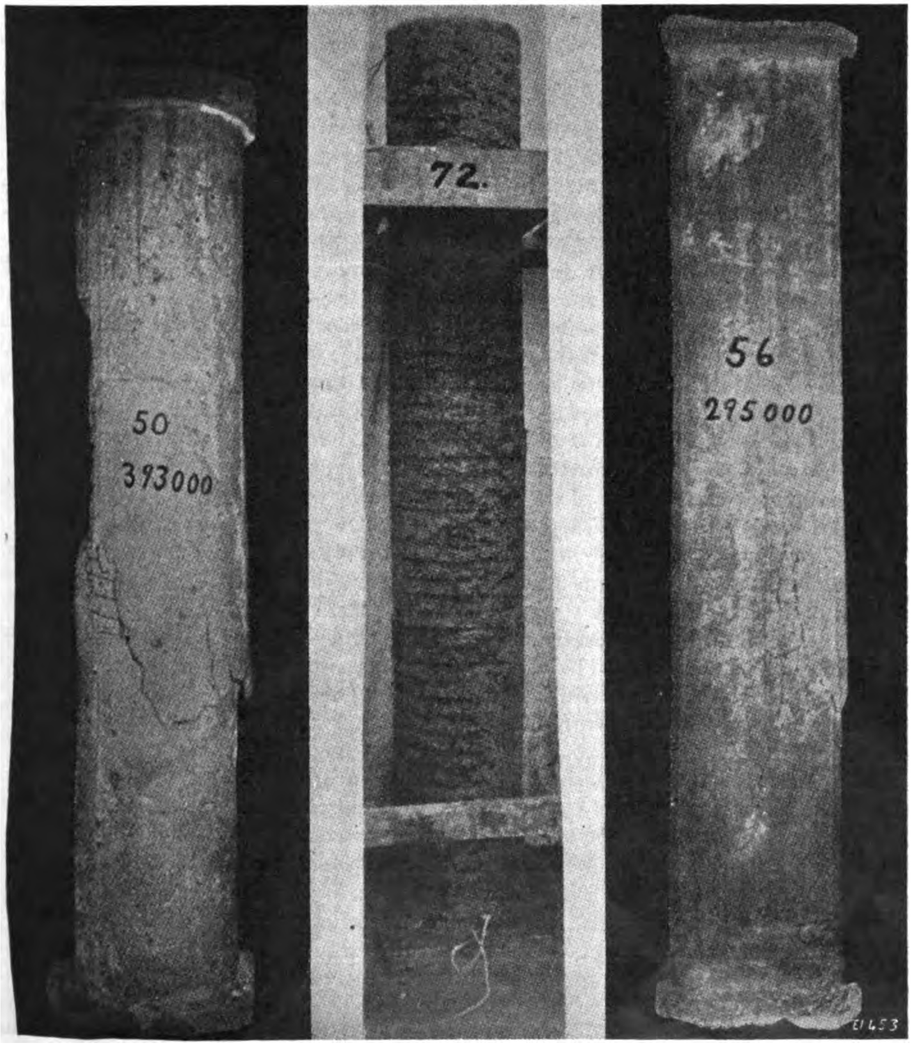
### COLUMNS CAST IN GYPSUM FORMS.

Results of tests of some of the columns of this sort tested up to this time are shown in Table I. In columns 58 and 59 the gypsum forms were 3 in. thick and of such diameter as to provide approximately 1 in. of protective concrete between this and the column reinforcement. In the fire test of No. 58 long, regular cracks appeared in the gypsum early in the burn, followed by the usual checking. After two hours of firing the gypsum began to fall away in blocks, and in a few minutes most of the concrete surface was exposed. Before column 59 was tested it was covered with expanded metal, and hoops of iron wire of large diameter were put on. The hoops appeared to have some effect, but, being exposed, could not last throughout the burn. The gypsum stayed in place for two hours and forty minutes.

The gypsum forms on columns 60 and 61 were 2 in. thick and of about as small a diameter as would accommodate the column reinforcement, with its tie wires. In the fire test No. 60 showed long, regular cracks in the gypsum early in the burn. The gypsum started to fall at the end of one hour and twenty minutes and a large part of the surface of the concrete was exposed within a few minutes. Before column 61 was cast, holes $\frac{7}{8}$ in. in diameter were bored through the sections of gypsum form, which had already been made before the other gypsum covered columns had been tested. Loops of wire were inserted in these holes, with their ends extending into the space to be filled with concrete. When the concrete was cast the holes filled to a great extent with mortar, affording, with the wires, fairly good anchorage for the gypsum. Neither this expedient nor that of hoops as on No. 59 could be considered practical for commercial work, but were resorted to for what information they would furnish, after the behaviour of No. 58 had been observed. The anchorage in No. 61 appeared to be fairly effective, as the gypsum covering did not start to fall away until after three hours and forty-five minutes of firing. The protection afforded up to that time, as shown by temperatures indicated by the thermocouples within the column, was exceedingly good.

### CEMENT PLASTER SUBSTITUTED FOR PROTECTIVE CONCRETE.

Column 63 was made originally 16 in. in diameter, providing approximately $\frac{1}{2}$ in. of protective concrete. When it was approximately 8 months old the surface was hacked and it was plastered with a mixture of 1 part Portland cement, 2½ parts sand and $\frac{1}{10}$ part by volume of hydrated lime. No hair and no metal binder was used. The thickness of plaster was 1 in., making a total thickness of 1½ in. of protective material. In the fire test, made 50 days after plastering, the plaster started to crack early in the burn. Cracking and bulging progressed steadily and at the end of 52 minutes the outer part of the plaster was commencing to fall off. The first, or scratch coat, was exposed over about half the column after 1 hour and 20 minutes of firing. Portions of the outer plaster continued to come off gradually during the remainder of the four-hour test. At the end of the fire test the first coat was in place and portions of the outer plaster remained.



Results of Fire Tests on Concrete Columns

Specimens photographed after completion of Fire and Load Tests. No. 72 was cast in form constructed by covering spiral reinforcement with metal lath, later plastered to provide protection.

Column 66 was made by wrapping metal lath around the spiral reinforcement, plastering on the metal lath with plaster of the same mixture as that used in No. 63

and casting the column in the form made in this way. Observations made during the making of this column indicate that this would be a less satisfactory way to build columns than to cast the column in the metal lath first and apply the plaster afterward. In the fire test the outer plaster came off earlier than in the case of column 66. The first coat remained in place throughout the burn. The earlier loss of a portion of the plaster is reflected in the higher final temperatures in the interior of the column.

Column No. 65 was made 16 in. in diameter with approximately ½ in. of protective concrete. At the age of 2 months and 23 days the surface of the concrete was hacked and the column was plastered with a special mixture that is used commercially as a roofing material. It consists mainly of Portland cement, sand and asbestos. The column was tested at the age of 4 months and 26 days. There was some cracking and separation of a finish coat, harder than the rest of the plaster, which covered the lower third of the column. The cracking, aside from this, was so slight as to be scarcely visible at any time during the fire test. At the end of the four-hour test, when the load was increased to 3480 lb. per sq. in., the deformation of the column was accompanied by a buckling and splitting of the plaster covering, most of which dropped off during the cooling. This column, failing at a load of 4,930 lb. per sq. in., when tested cold, after the fire test and the load test in the furnace, gave somewhat better results than seem consistent with the temperatures attained in the column. Too much importance should not be attached to this single test of a column protected by this material; it does indicate, however, that it is possible to produce a material which, when applied in the form of a plaster to gravel concrete columns will stay in place under fire conditions and afford good thermal protection. A considerable number of combinations of materials of moderate cost are being examined with a view to determining what can be accomplished in this direction.

## SUMMARY OF RESULTS.

The results of column tests available for this report contribute additional evidence that gravels of three distinct types, all high in quartz but in different forms and in different amounts, give less satisfactory results under fire conditions than concretes from limestone, trap rock and blast furnace slag aggregates. The expansion behaviour of concrete in which these gravel aggregates are used appears to have a strong tendency to cause spalling, especially in round columns with spiral as well as vertical reinforcement, and in square columns with vertical reinforcement only. Coarse-grained granite pebbles and gneiss pebbles shatter or disintegrate under severe fire conditions. Columns of these types from trap rock concrete and from blast furnace slag concrete show no tendency to spall or to crack to any important extent under the conditions of the standard four-hour fire test. In all cases columns from trap rock and slag aggregates have shown themselves capable of bearing considerably more than twice their respective working loads, before cooling, following the four-hour fire test.

Round columns of gravel concrete vertically and spirally reinforced, cast in forms made from gypsum and left on, for fire protection, gave results varying with the length of time the gypsum protective material stayed in place. Results of a test of a column in which anchorage was provided for the gypsum indicate that a light metal binder in the gypsum may be effective.

Observations made in casting columns in forms made by covering the spira reinforcement with metal lath indicate that such an expedient would be practicable in cases in which it might appear desirable to substitute other protective material for the protective concrete ordinarily provided. Gravel concrete columns with vertical and spiral reinforcement over which part or all of the thickness of the protective covering had been provided in the form of cement plaster gave better results than columns of the same type with the usual concrete protective coating, previously reported, but much poorer than columns from trap rock, blast furnace slag and limestone aggregates with protective concrete in the usual form. The comparatively poor results shown by these plaster protected columns are consistent with the observations reported, namely, that a large part of the outer coats of plaster separated and fell off, leaving practically only the first coat for protection during the latter part of the fire test.

One column in which the protective covering was a special mixture, mainly asbestos, Portland cement and sand, applied in the form of plaster, withstood the test of 3,480 lb. per sq. in. at the end of the four-hour fire test, and failed when cold at a load of 4,930 lb. per sq. in. Temperatures in the steel were somewhat lower under this protection than with concrete protection in the trap rock and the slag columns.

### CONCLUSIONS.

The results reported at this time afford additional evidence in support of the conclusions reached last year, especially as to the important differences in the fire-resistive properties of concretes from different aggregates. The results of tests of gravel concrete columns are consistent with those made previously, and the conclusion that gravel concretes from gravels of a number of different types are inferior in point of fire resistance to concrete from a number of other aggregates is obvious and unavoidable. Due to differences in age and possible differences in conditions of ageing, the results shown by the trap rock and the slag concrete columns are not strictly comparable with those of the tests of limestone columns previously reported. The observation that neither the trap rock nor the slag concrete appears to have any tendency to spall or any other malignant tendency under the conditions of these tests is important and reassuring.

The Bureau of Standards tests are being continued, and the results of these additional tests will be reported on at a later date.

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## MEMORANDA.

**Concrete Telephone Booths.**—Wooden telephone booths appearing along the tracks of electric railways in America are, before long, to be replaced by concrete ones. A new design has recently been brought out by a Chicago manufacturing concern, who are making use of concrete in the construction of them. The booths are made in three sections, body, base, and top, and are thus easy to transport from one place to another, and are said to be lighter in weight than most booths. Electrical telephone connection is such that the locking and unlocking of the door automatically cuts out and cuts in the telephone. Provision is made within the booth for a wooden shelf upon which to place the telephone. Upon the floor is placed an extra wooden floor lightly insulated to act as a positive means of insulation. A panel in the door provides for sufficient light while telephoning.

**Concrete for Overhead Shafting Lines.**—In connection with the erection of the Halesowen Spelter Plant reinforced concrete was employed in a somewhat novel way. A number of concrete A frames were employed. The frames are of two heights—viz., 11 ft. 6 in. and 10 ft. 3 in.—and consist of sloping legs 9 in. by 6 in. in section spaced at 3 ft. 3 in. centres at the bottom, decreasing to 2 ft. centres at the top, tied at approximately 5 ft. from the ground level by a 9 in. by 5 in. member, and at the top by a 9 in. by 9 in. beam to which the shafting is fixed direct. The work was carried out by the Indented Bar and Concrete Engineering Co., Ltd., of Queen Anne's Chambers, S.W.

# RECENT BRITISH PATENTS RELATING TO CONCRETE.

*We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Mr. J. Harold Beaumont, Registered Patent Agent, of Messrs. Andrews and Beaumont, 204-6 Bank Chambers, 29 Southampton Buildings, W.C.2. The last article appeared in our issue of December, 1919.—ED.*

**Reinforced Concrete Slab Buildings.**—*No.* 134,007. *W. T. Watson, Station Road, Yate, near Bristol. Dated October* 21/18.—According to this invention all the component parts of a reinforced concrete slab building are formed separately from each other, usually to standard sizes, strengths and shapes ; these component parts consist of concrete posts, reinforced concrete sills extending from post to post and tongued or otherwise connected to the posts and morticed to receive reinforced rebated jambs for the windows tenoned into the sills. Headplates are provided which are morticed to receive the tops of the jambs and metal loops are provided on the headplates to engage metal pins cast in and projecting from the top of the posts, and slabbing is laid on the framework.

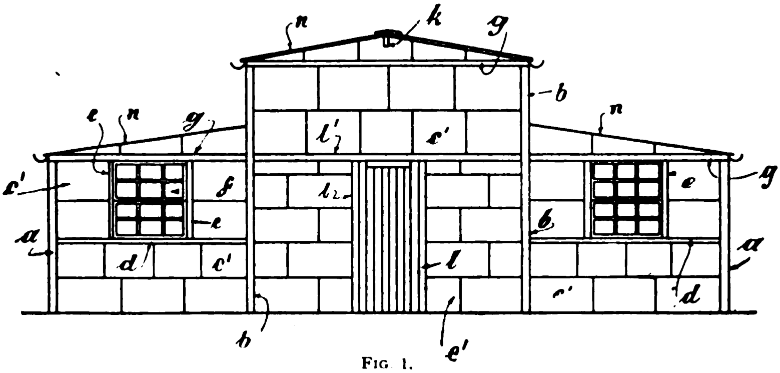


FIG. 1.

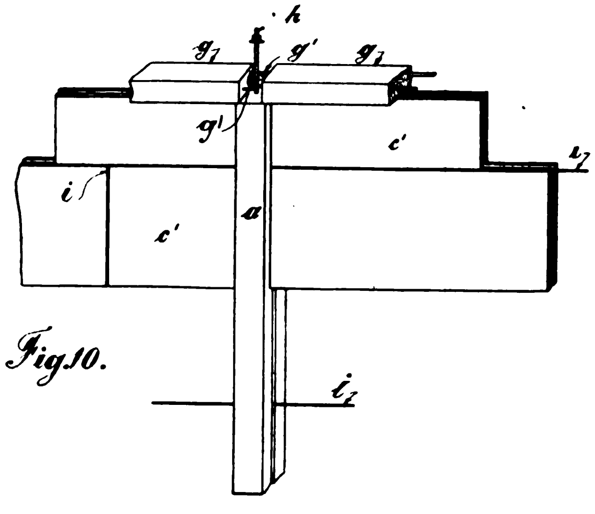


Fig.10.

A number of constructions are illustrated in the Specification. In the building shown in *Fig.* 1, the reinforced concrete posts (*a*, *b*) are first erected and a dwarf wall is then built on a damp course by means of slabs (*c*) fitting in grooves in the posts up to the level of the sills (*d*). Grooved jambs (*e*) are morticed into the sills the top surfaces of which are grooved to receive slabs ($c^1$). Reinforced headplates ($g$), shown in detail in *Fig.* 10, have fixed therein metal loops ($g^1$) which are bonded with the reinforcement of the headplate and engage metal pins ($h$) cast in and projecting from the tops of the posts, the space between them being filled with mortar.

**Hollow-block Floors.**—*No.* 134,269. *G. E. Clare*, 2, *College Road, Harrow, Middlesex. Dated October* 14/18.—This invention is an improvement upon the inventions described in Specifications Nos. 14,267/15 and 102,814.

The reinforcement in accordance with the present invention consists in an inverted T bar ($e$) provided with a perforated or thickened web to increase adhesion.

Fig. 1.

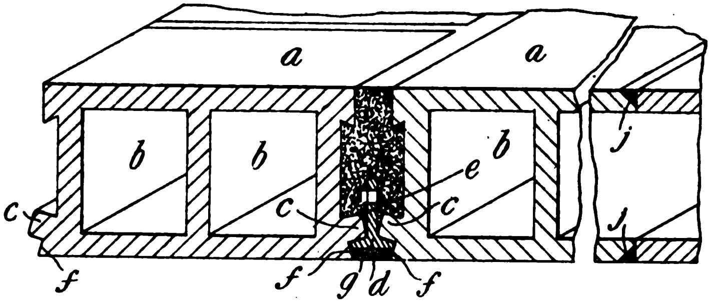
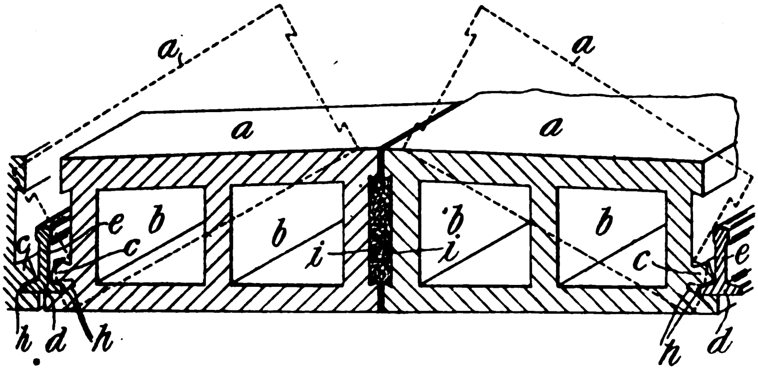


Fig. 2.

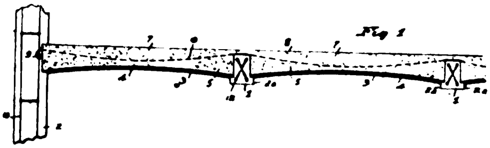


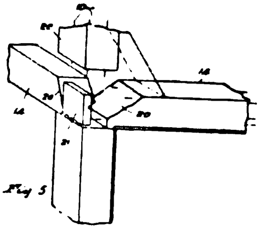
The hollow blocks ($a$) are provided with lips ($c$) which rest upon the flanges of the T bar. In the form shown in *Fig.* 1, these lips are provided at each side of the block but in the alternative construction shown in *Fig.* 2, two blocks are employed for each T bar.

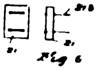
**Reinforced Concrete Floors.**—*No.* 134,591. *J. J. Blackburn*, 459, *Worsley Road, Winton, Patricroft, Manchester. Dated October* 29/18.—According to this invention reinforced concrete floors are formed with a series of beams having shouldered lower edges and the spaces between the beams are enclosed with upwardly cambered composite boards or similar thin membranes which rest upon the beams and are covered above with reinforced concrete in which steel netting is placed in catenary form.

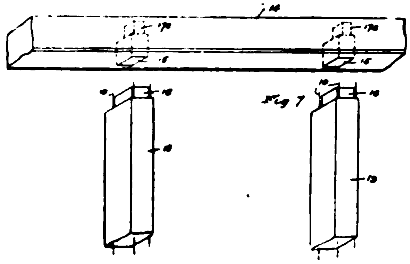
The shoulders (2*a*) of the beams (1) serve as abutments for the arched boards (3) and a layer of concrete is first spread over these boards ; steel wire netting or like reinforcement (6) is then hung over the beams to rest on this concrete layer whereupon the remainder of the concrete for the floor is cast. The ends (9) of the reinforcing wires (6) are previously interconnected with the reinforcing wires (10) of the vertical posts.

In setting up the framework of the building, where an outer beam (14) is fitted, it may be supported by vertical reinforced concrete intermediate posts (13), the beam (14) being morticed at (15) to receive the upper ends of these posts on which tenons (16) are provided. Where the ends of the beams (14) rest upon vertical corner posts (19), they are chamfered off at their upper surfaces (20) and a small cement block (21) is placed on the top of the corner post to support the foot of the upper corner post (22) when the latter is lowered into position.









**Concrete-slab Walls.**—*No.* 134,375. *A. Mitchell,* 1, *Basinghall Square, Leeds. Dated November* 19/18.—Concrete cavity walls are constructed in accordance with this invention by means of slabs 1 provided with distancing ribs 2, which are so placed as

Fig. 1.

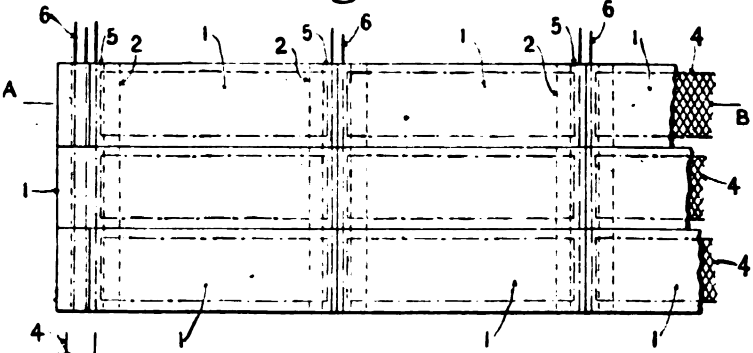
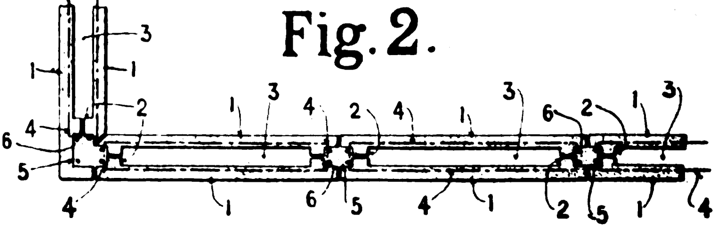


Fig. 2.



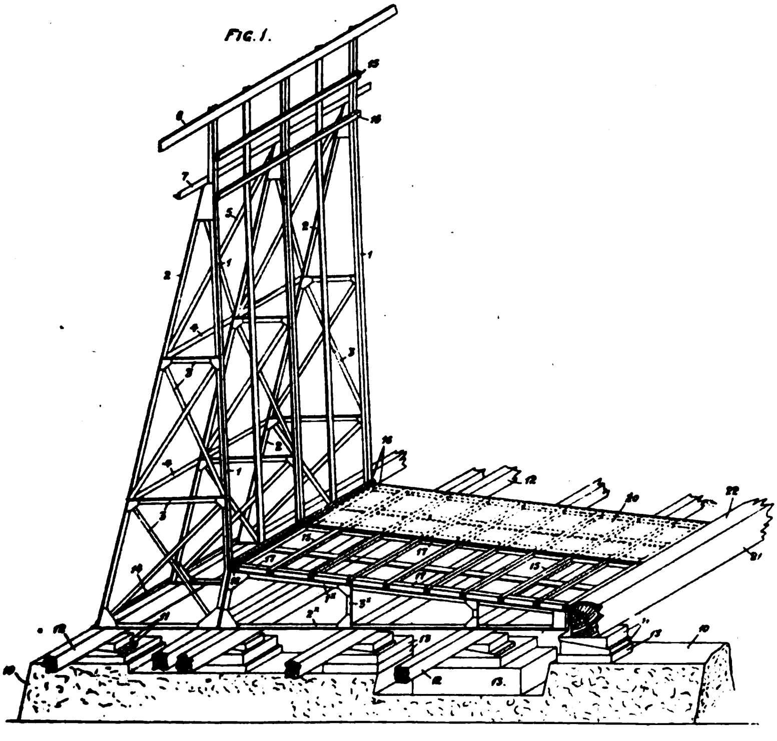
to leave vertical cavities into which reinforced concrete columns are cast. Each slab has inserted therein a horizontally arranged reinforcing wing 4 of expanded metal having its ends projecting outwardly at right angles to the slab.

The angles of the walls are formed by employing compound slabs having inner bevelled edges and external returned ends which allow them to be set at right angles to each other.

**Shuttering for Concrete Ships.**—*No.* 134,860. *F. Brasendale, Laurel Bank, Lymm, Warrington, Lancs. Dated May* 21/18.—Shuttering for concrete navigable vessels constructed in accordance with this invention comprises a number of self-contained sections or units made of metal lattice framework, the edges of the sections abutting against each other and being connected together when in position; the sections are mounted upon movable supports.

The shuttering or moulding surfaces proper of these sections consist of continuous metal sheets which are riveted or otherwise secured to the front bars of the sections on to wood bearers fixed to them. The units are supported by concrete blocks and set upon wedges which rest upon timber stools, thus enabling vertical adjustment of the units to be effected.

FIG. 1.

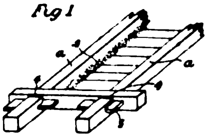


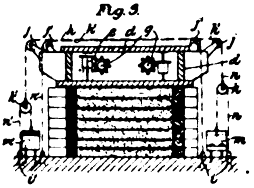
The forms of the units depend, of course, on the portion of the vessel to which they belong; *Fig.* 1 represents the shuttering for a mid-ship section.

The units are in two parts disposed at an angle to each other, the upper part consisting of front members (1), back members (2) and diagonal bracing members (3); the lower part consists of upper and lower bars 1*x*, 2*x* and bracing members 3*x*. Transverse bracing members (4, 5) are provided in some cases. In the form shown in *Fig.* 1, the units rest upon longitudinal wooden sleepers (12) supported on double wedges (11) which themselves sit on stools (13) supported on concrete sleeper walls (10).

The inner faces of the units are provided with longitudinal bearers (15), which may be of timber, and a corner bearer (16); transverse fillets (17) are provided between the bearers and metal sheets (20) are secured to these to act as the moulding surface proper.

**Making Concrete Slabs.**—*No.* 134,936. *F. G. Lynde, The Eaves, Belvedere, Kent. Dated November* 14/18. According to this invention concrete slabs are moulded one at a time in moulds arranged one above the other in such a manner that the moulds can be dismantled to leave a stack of slabs to mature without any disturbance of the concrete.





The concrete is tamped by stamps (*e*) operated seriatim from a tappet shaft (*g*) carried by a frame (*d*) which is adapted to be pressed down by pulley tackle (*n*, $n^1$). The moulds comprise side members (*a*) which are halved where they cross and leave a clearance (4) which is taken up by wedges (5). Sand may be placed in the moulds to give bevelled edges to the slabs.

**Reinforced Concrete Slab Buildings.**—*No.* 134,922. *J. S. Bains, " Glenart," Coronation Road, Great Crosby, Lancs. Dated November* 13/18 *to March* 24/19. (*Four cognate Provisional Specifications.*)—This invention comprises a method of constructing reinforced concrete slab buildings and is especially intended for small buildings such as cottages, farm buildings, poultry houses, etc.

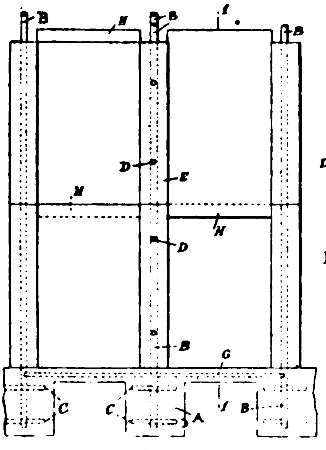


Fig. 1.

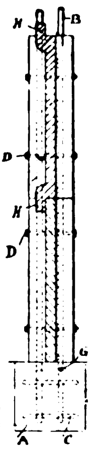


Fig. 2.

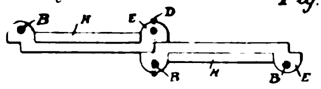


Fig. 3.

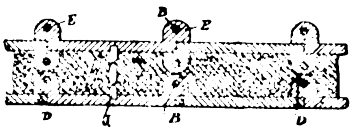


Fig. 4.

A block of concrete (*A*) is first cast in a hole in the ground, rods (*B*) surrounded by plates (*C*) being placed therein before the concrete has set; distance plates (*G*) may be employed to space the rods (*B*) at the requisite longitudinal distance apart.

Reinforced concrete slabs, with rebated sides provided with ridges provided with holes, are then strung on the rods (*B*) with ridges alternately at front and back as shown in *Figs.* 2 and 3. Flanges (*H*) may be provided to act as supports to successive higher slabs.

By the use of three rods (*B*) a cavity wall can be constructed as shown in *Fig.* 4.

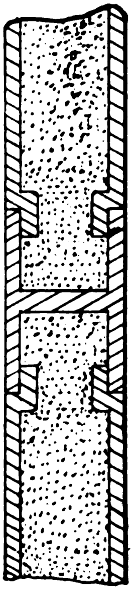


Fig. 11.

Walls can also be constructed by the use of posts of H section, *Fig.* 11, co-operating with reinforced concrete slabs with rebated edges.

Similar reinforced slabs can be employed for building cycle sheds, the component parts being fastened together by bolts or dowel pins.

**Concrete Glazing Bars.**—*No.* 133,794. *A. E. Drown, 20, Victoria Street, Westminster, S.W.*1. *Dated October* 22/18.—A reinforced concrete glazing bar constructed in accordance with this invention has metal clips (13) the ends (15, 16) of which are secured to the upper reinforcing bars (2, 3) and which serve to retain the latter in position when the concrete is being cast. The screws (19) or other means for holding the glass against the glazing bar engage in these clips; a metal washer (23) is pressed by the screw head on to a bituminous felt washer (22) and thence to the glass sheets (20) which rest on asbestos packings (11, 12) and, in the form shown in *Fig.* 1, upon a packing strip (6) of bituminous felt.

*Fig.1.*

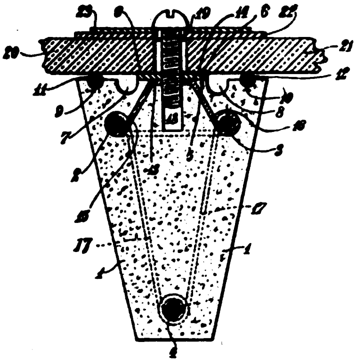
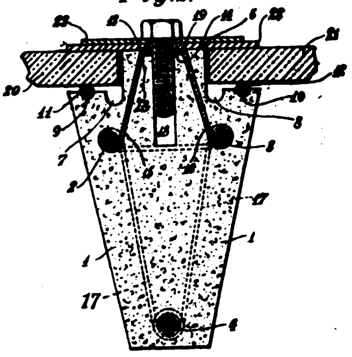


*Fig.2.*



**Reinforced Concrete Floors.**—*No.* 135,128. *C. Marques,* 11, *Osborne Road, Forest Gate, Essex. Dated May* 9/19.—This invention comprises an improved form of combined floor and ceiling construction of the type consisting of reinforced concrete beams of T-section placed alternately upright and inverted.

**Fig.1.**

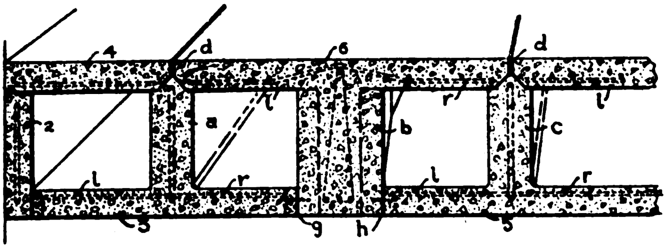
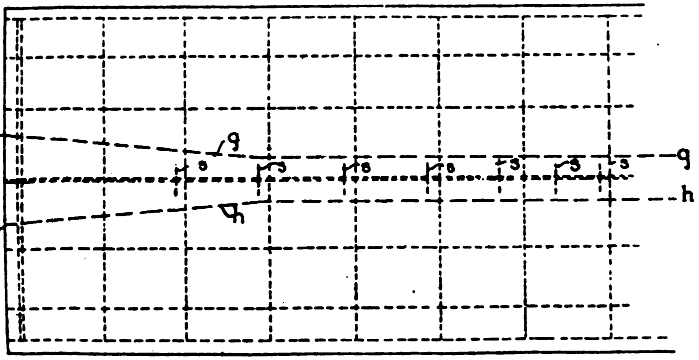
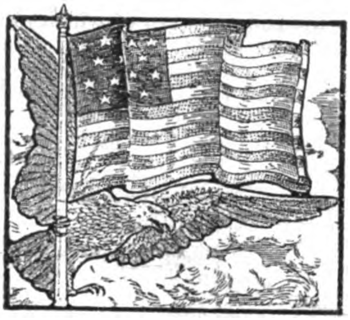


**Fig.2.**



The invention consists in forming the web (*g*, *h*) of the upright T-beams gradually wider towards the supports in order to give larger bearing surfaces.

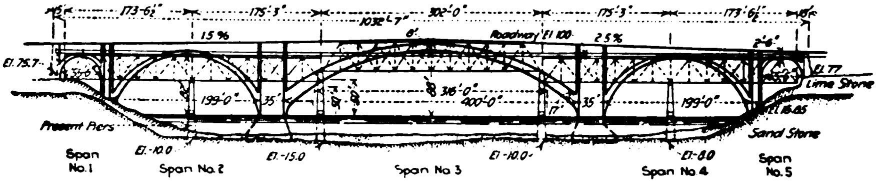


# TWO INTERESTING EXAMPLES OF REINFORCED CONCRETE CONSTRUCTION IN AMERICA.

*In the following pages we give one or two examples of recent reinforced concrete work in the United States. For our particulars and illustrations we are indebted to "Engineering News-Record." The first, the Arch Span across the Mississippi, is said to surpass the Risorgimento Arch across the Tiber by 62 ft., and there are several interesting features in connection with the Oil Tank built for the Panama Canal.—ED.*

## LONGEST CONCRETE ARCH SPAN BEING BUILT AT MINNEAPOLIS.

A 400-FOOT concrete arch, which will be the longest-span concrete arch in the world, is being built at Minneapolis, Minn., constituting the main portion of the Franklin Ave. bridge over the Mississippi. It will consist of two separate ribs of 400-ft. span between faces of piers, with a rise of 88 ft. above the springing line, at high-water level. The main arch is flanked at each end by one arch with a clear span of 199 ft. and one of 55½ ft., the total length of the bridge over abutments being 1,032 ft. The piers will rest on the solid rock of the river bed. Each rib of the main arch will be 12 ft. wide, with a thickness of 17 ft. at the springing line and 8 ft. at the crown, carrying spandrel columns with cross-girders to support the concrete deck. The rib reinforcement consists of frames, 6 in. by 6 in. by ½ in. angles being used in the large span and smaller angles in the approach spans. The ribs are on either side of the present steel truss bridge, which thus affords facilities for the construction work. The 400-ft. span was necessary to give a clearance of 50 ft. by 300 ft., as required by the United States Government for navigation purposes.



FRANKLIN AVENUE BRIDGE ACROSS THE MISSISSIPPI AT MINNEAPOLIS WITH 400-FOOT REINFORCED CONCRETE CENTRAL ARCH.

The present steel bridge is being used for traffic as well as for construction purposes, Its roadway is 18 ft. wide, so that by the removal of the sidewalks the new arch ribs placed 25 ft. apart, will clear the steelwork, which will be removed when these ribs are completed, the floor for the 25-ft. space between them being placed after the removal of the old structure. This floor will be cast ashore, and will be placed by a traveller from the completed floor over the arch ribs.

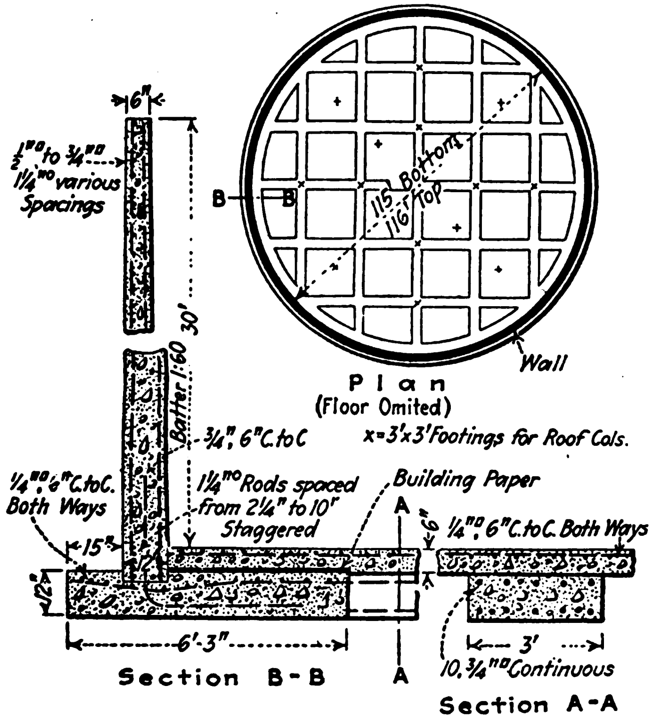
Work was commenced in June, 1919, on the work and concrete-mixing plant, located on the Chicago, Milwaukee & St. Paul R.R. tracks in southeast Minneapolis, about 2,000 ft. from the east end of the bridge. The material will be handled by a conveyer system, and service between the bridge and the plant will be performed by two gasoline locomotives on a 36-in. track. This plant is nearly completed.

In July the cofferdam framing was commenced on a flat piece of river shore about one-half mile up the river from the bridge site. These frames were then floated down and placed in position for pier No. 1. This cofferdam will be 80 ft. up and down stream, and 64 ft. wide, divided into two compartments 40 ft. by 64 ft., by 28-ft. 14-in. arched steel sheet piling, which also will surround the entire cofferdam. This pile driving has been completed for the downstream compartment. The piles are driven through boulders, gravel and limerock debris to and into the underlying sand rock. Excavation with a clamshell bucket was commenced before the pile driving was finished.

The general design of the bridge and the design of the great arch span were made by F. W. Cappelen, city engineer. The city is doing the construction by its own forces. Contracts have been let for the arch reinforcement. The construction of falsework for arch No. 2 has been commenced, and it is planned to work through the winter. It is expected that the bridge will be completed in 1921 at a cost of about $500,000.

### LARGE CONCRETE OIL TANK BUILT FOR PANAMA CANAL.

Mr. R. C. Hardman, engineer-designer the Building Division, Panama Canal, states that steel shortage during the war, together with the existence of a large supply of 1¼ in. round bars which were purchased for another project and not used, determined the use of reinforced concrete for a 55,000 bbl. fuel-oil tank constructed in 1918 at the Mount Hope Oil Tank Farm, near the Atlantic terminus of the Panama Canal. As this farm contained a number of steel tanks of similar capacity, the same general dimensions were used for the concrete tank, i.e., 115 ft. in diameter and 30 ft. in height.



Details of Concrete Fuel-Oil Tank for Panama Canal.

The tank is located on a hill about 30 ft. above the surrounding country, and rests upon a foundation of red clay. As a measure of protection against varying soil conditions the foundation consisted of a gridiron of ribs, as shown in the drawing, reinforced top and bottom, to enable them to take care of any uneven settlement at soft spots and prevent cracking of the floor slab. The tank walls being circumferential, the design was very simple. As the temperature changes on the Isthmus are small, no provision was made for temperature stresses. Elongation due to stress is provided for by sliding; it will be noted in the drawing that the wall is secured to the footing under it, the whole being independent of the floor slab and ribs. By this construction changes due to elongation can take place readily. Building paper was used between the floor slab and the wall footing. No special means of securing a tight joint between wall and wall footing were used. In two fuel-oil tanks designed by the writer for the Panama Gas Co. and the Colon Gas Co. a thin metal strip was imbedded in the footing and the walls built over it.

Footings for roof columns, seventeen in number and 3 ft. by 3 ft. in size, were provided at the centre of the tank and at the third points of the radius with 45° separation. The original design called for a wooden roof with tar and gravel covering, but was later changed to the ordinary steel-plate construction, as is customary on steel tanks, and is required of privately owned oil tanks on the Isthmus.

The tank is provided with an 8 in. swing-joint supply and discharge pipe, 30 ft. in length, so placed to draw off oil at any depth, and operated by means of a hand winch on the roof. The pipe enters the tank through a cast-iron sleeve with circumferential ribs on the inside for lead caulking. Two cast iron clean-out holes with blind flange covers are provided near the bottom of the tank, as well as a 3 in. drain for drawing off water which collects at the bottom of the oil. Entrance to the tank is by inside and outside ladders built into the wall, and a manhole in the roof.

Steel stresses of 16,000 lb. per sq. in. were used. Unit weight of oil was taken at 54 lb. cu. ft.

Forms for the tank were made in sections about 6 ft. in height and 10 ft. in length, bolted together circumferentially, the inside and outside forms being likewise held together by bolts. Lifts of 6 ft. of wall were poured, and the forms removed, raised and placed for the next lift, thin strips being placed between inside form sections at each operation to take care of the increased circumference due to batter.

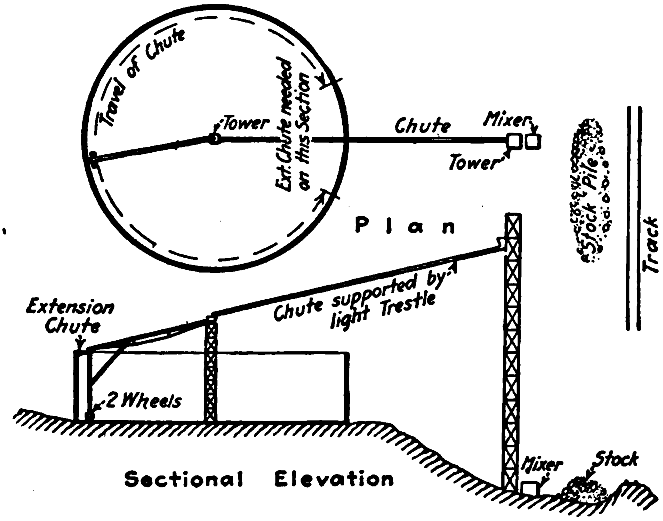
Immediately upon removal of the forms all suspicious looking spots were cleaned, out and pointed up, and the whole exposed surface given a plaster coat of mortar with steel trowel finish on the inside and wooden float finish on the outside.

The concrete was placed circumferentially in layers about 12 in. in depth until the 6 ft. section was filled. The type of form used is not to be recommended, as in a thin section with such a large percentage of steel it is extremely difficult to secure good placing at the bottom of the deep form. In the construction of a similar tank by the writer in Colorado a few years ago the outside forms were built up complete, the inside studs and braces placed and the lagging nailed on immediately in advance of the pouring, so that there was never more than about 8 in. from the top of the form to the old concrete. The process can be made continuous by this method also.

The concrete was placed by means of a chute supported at its lower end by a ladder construction mounted upon a carriage having two wheels placed to travel circumferentially, and its upper end carried by a light tower placed in the centre of the tank. The ladder construction enabled the chute to be carried at any desired elevation. This revolving chute was fed by a chute from a hoisting tower placed at the foot of the hill alongside a track from which material was handled. The skeleton sketch illustrates the plant sufficiently well.

The concrete was of approximately a 1 : 2 : 4 mix, the proportions used at the start of the walls being 1 cement, 2¼ sand and 3¾ crushed stone. These proportions were determined by G. C. Bunker, physiologist, as giving the densest mixture with the materials available. However, a trial proved that the mix was extremely difficult to properly place, owing to poor flowability into forms containing such a large percentage of steel, so changes were made and graded gravel used instead of crushed stone. The final mix adopted was 1 cement, 2 sand and 4 gravel, graded ¼ in. to 2 in. in size, mostly of the smaller sizes. Tests on this mix showed a crushing strength of from 1,971 to 2,246 lb. (3 sets) at 29 days, and an average of 2,898 lb. at 28 days.

It was desired to use hydrated lime as a waterproofing and to insure better placing, but none was available on the Isthmus. Upon completion the tank was filled with water, which gave it an overload of about 16 per cent., and kept filled for about two weeks. For the first few days numerous minor leaks developed, mostly in the form of seepages, which finally entirely stopped. The tank was then emptied and thoroughly dried and given a treatment on the interior in accordance with the specifications of the Bureau of Yards and Docks, Navy Department, for concrete tanks containing fuel oil.



How Concrete was placed in Panama Oil Tank.

This consisted of a spray coat of a 7½ per cent. solution of calcium fluo-silicate (1 gal. to 100 sq. ft.) for a height of 2 ft. up from the bottom. After 24 hours' drying three coats of spar varnish with 20 per cent. volatile mineral spirits (a hydrocarbon, distillate) were sprayed on under a pressure of 60 lb. at intervals of 24 hours (1 gal., to 200 sq. ft. each coat).

Above the 2-ft. mark and to the top the calcium fluo-silicate was applied as above, followed at 24-hour intervals by two coats of glutrin painted on (1 gal. to 400 sq. ft. each coat). The tank was gradually filled with oil, with the development of a few minor leaks which quickly closed up.

The design and construction of the tank were carried out by the forces of the Building Division of the Panama Canal, with Hartley Rowe, resident engineer; T. C. Morris, assistant engineer, and the writer as engineer-designer.

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## RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

### Recent Papers and Discussions.

*It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.*

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## THE CONCRETE INSTITUTE.

# REINFORCED CONCRETE FENCE POSTS.

**By E. F. W. GRIMSHAW.**

*The following is an abstract from a paper read before the Concrete Institute at their 92nd Ordinary General Meeting.*

THE matter before us, namely, that of Reinforced Concrete Fence posts, is not one requiring a very high standard of knowledge, yet this simple commercial article has a real value in the everyday requirements of a vast number of people and of public companies.

Fences are a very necessary evil—no one likes them, and no fence, except a hedge, can be anything but ugly—but it may be claimed that these posts are no uglier than any other form of artificial post, and for economy are hard to beat.

The figures given here are, of course, those of pre-war days, but there appears to be little use in altering the actual principle of the comparisons of prices of fences ; as if we add up-to-date prices all will come out much the same in the long run.

The prices here are for railway fences, where the posts can be delivered by rail near the place where they are required—no carting has been allowed for.

Working upon a mile of railway fencing, the cost for new all-wood fence (post and rail) of the cheapest description was about 1s. 6d. per linear yard complete, whilst the cost of a new concrete post and seven-wire fence would be about 1s. 9d. per yard erected complete. After about ten years the wooden fence is worn out, but at the same period the concrete post should be as good as new ; thus at the start of the eleventh year a railway company would be spared an expenditure of about £130,000 per 1,000 miles of line, taking both sides of the line. We may assume that at the end of 20 years the concrete posts will be still good, but that the wires will require renewing. Taking the wires at 4d. per yard and labour for same at 2d., this would represent about £45,000 in 1,000 miles of line, or £90,000 on both sides of the line. Calculating on an ordinary basis the wood fences will, at the commencement of 21 years, have cost three times 1s. 6d., say 4s. 6d. per yd., whilst the cost of concrete posts will be still 1s. 6d. plus 6d.=2s. per yd. Accordingly there will be a saving of 2s. 6d. per yd., and roughly a saving of £230,000 in 1,000 miles of fence at the end of 20 years, allowing £10,000 for interest on extra first cost of the concrete fence. There must be added to above cost of the wood fence the constant expense of men's time in clearing away and digging along it to prevent fire, a work which is not required for concrete posts in any case. If a preservative is used for the wood posts, then the first cost is greater, and even so they will burn all the more freely

The present prices of materials have, of course, run up to figures which throw the above into the shade, but this makes little difference, as the price of labour is so high now that any saving in renewals will still further add to the advantage of an article that will last longer.

**Cement.**—In the manufacture of these posts the same factor applies as to most concrete work, *i.e.*, the more cement that is used the better; being of small section the posts require a strong mixture, and in most of his work the author used one of cement to three of aggregate.

**Aggregate.**—Many users of concrete disagree about the aggregate, both as to the amount in proportion to the cement and again in the proportion of sand to shingle—but in the case of posts the less sand used the better. I believe firmly in well mixing dry, and if cost would permit I should dry all sand before mixing.

**Dry Mixing.**—Mixing wet is not the same—if we get material badly mixed dry, the particles of cement will not reach the badly mixed portion and will, of course, cause trouble; whereas if well mixed dry—even if the wet mixing is not perfect—the damp of the concrete will reach any part after the rough mixing has been done, and thus we have sound work. It is most important in reinforced work that the cement itself should get well round the reinforcement, and then there is no fear of rust setting up.

**Reinforcement.**—In his experiments the author has used all sorts of sections—round, square, oval, indented bars, etc.—but found that for ordinary posts from 5 ft. to 7 ft. the most suitable reinforcement was 5-16th in. round iron; iron is the best. The modern high tensile steel sets up rust at such a rate that it is very troublesome, and as these posts do not require such great strength there appears little use for it. Experiments showed that 5-16th in. gave much better results than ¼ in., the latter being inclined to yield for want of adhesion. A post 4 in. square at ground level and 4 ft. 6 in. out of the ground and pulled from the top, withstood about 10 to 15 cwt. when about three months old.

**Horizontal Reinforcement.**—Horizontal reinforcement tended to make posts crack at the position of the bindings. The intention of these bindings is to keep the reinforcement in its place in the moulds; but in these posts the extra cost is not worth it—of course, in columns and certain beams or girders in compression, binding is necessary.

**Moulds.**—For ordinary fence posts a wooden mould will be found quite satisfactory, and about three or four hundred posts can be turned out with same, provided reasonable care is exercised.

**Manufacture.**—The posts should, as far as possible, be made in places where the necessary materials are at hand.

It has been asked whether the posts require any reinforcement. A well-made post, given ample time to set (say, six months), and handled with reasonable care and once it is fixed in the ground, would probably stand most of the ordinary pushing and scratching of horses and cattle, but if horses kicked such a post it would most likely break, whereas if reinforced it would seldom even crack; and even if cracked, the reinforcement would hold it for many years.

**Fixing.**—The usual method is to dig a hole 2 ft. or thereabouts and ram the posts in, but a very strong and economical method is to put a small shovel full of wet cement in the bottom of the hole, place the posts on this, and then fill in to within about 6 in. of top of ground with earth, then put a collar of concrete about 3 in. thick round the post and finish the last 3 in. with earth to make the ground look normal. This does not require much concrete and makes a first-class piece of work.

**Standardisation.**—Concrete posts lend themselves very well to standardisation.

**Weight of Posts.**—The weight of concrete posts is a matter for consideration; and here again a great deal may be saved by careful design. A properly designed tapered post is the right thing in nearly all cases.

**Generally.**—There would still appear to be a great lack of knowledge on the subject of reinforced concrete, and the very fact of its not requiring such high-class knowledge as other branches of engineering demand has led to the belief that any fool can be a reinforced concrete engineer and make anything anywhere. There also seems to be a perfect mania for economy in cement in all concrete work. The amount of expense and care that is taken in various ways to avoid using cement in many cases outweighs the saving, and results in bad work, which in many cases would have been avoided if plenty of good cement had been used. Moreover, many cases of failure in plain concrete have occurred merely because those responsible did not know that a little reinforcement in the right place would have saved the situation—this applies very often to retaining walls and similar structures.

## DISCUSSION.

**Lieut. W. J. Pickering, R.E.**, said that eight years ago he had built two little fences having posts attached which were 6 in. by 6 in. at the bottom and 4 in. by 4 in. at the top. He had made the rails in monolithic concrete as well 4 in. by 4 in.; it was 2 to 1 concrete, and there was no sign of rust yet in the reinforcement anywhere; ⅜ in. rods were used throughout in that case. Recently for his own domestic use he had made a clothes post 5 in. by 4 in. in a triangular section. That was made entirely of sand and cement of the proportion of 2 to 1 and had stood considerably more than 15 cwt. applied to the top. It had not cracked, but had in fact broken the steel wire attached to it. He thought it was a mistake to have such open mixtures of sand and aggregate. If the steel needed protection it should have a proper amount of sand with it to keep out air and moisture. He did not think this would detract much from the strength of the concrete provided the sand and cement were proportioned correctly; probably the want of a correct proportion of sand and cement was the real cause of the evil.

**Mr. E. Fiander Etchells** said he had several suggestions to make as to designs: (1) The proportion of 1 volume of cement to 3 volumes of aggregate or other material was good. (2) As a rule 4 rods should be used. (3) All ends of all bars should be hooked or turned over. (4) Horizontal binding was not necessary. (5) The percentage of reinforcement in practice varied. In the case of 4 in. by 4 in. posts it was, as a rule, about 1 per cent.; in the case of 16 in. by 16 in. posts it was only about half of 1 per cent. Those were very heavy posts and used for very heavy gate posts for factories. In the design of the posts practice and practical experience were the best guides. In the case of railway gates the bending moment was calculable and the over-turning moment was calculable, but allowance should be made for a crowd of people hanging on the gate. You should not take the net weight of the gate. In the case of smaller posts the contingency was not so great. With regard to the general effect of unknown blows, these were incalculable, so it would be poor economy to design every one of 10,000 posts as though that post was going to receive some exceptionally severe treatment. It would be better to take a fairly reasonable line and let the breakage of posts be an accident which could be remedied by the insertion of a new post. It would be very expensive indeed to make every post fool-proof or accident proof. One other point was that in some posts where there were no wires between, but square or round bars, it was found that the posts cracked at the point where the bar was inserted. This was more frequently the case where square bars were used because there were sharp angles formed in the concrete, and in some cases you might find nearly half of the concrete posts cracked where the bars were inserted. That might sometimes be prevented by having a round hole in the concrete, putting in your square bar and grouting up. An advantage of the square bar was, of course, that it was not so convenient for gymnastic purposes if it was placed in front of cottage property. A question was raised by the writer when he said, "I found that a post 4 in. square at ground level and 4 ft. 6 in. out of the ground and pulled from the top withstood about 10 to 15 cwt. when about three months old." I never had a case of a post reported for breaking, except in one instance in which I found no reinforcement had ever been put in the posts." He (Mr. Etchells) would like to know what was the direction of the pull, vertical or horizontal. In that connection one must bear in mind that the end post of a series might have to act as a straining post. Of course it should have diagonal or raking struts, and again it would be poor economy to make every post able to withstand the horizontal force which might be applied by means of the wires in between the posts.

**Mr. Archibald Scott** asked what was the lightest post that had been found in practice could be used for a normal 4 ft. fence?

**Lieut. L. S. White** said they had been speaking of posts separating fields for enclosing cattle. He would like to speak of some posts that he had seen in France. When he was at Wimereux he saw some posts along the sea front. Of course these had to withstand a somewhat different action from that of the field posts, and he did not know whether it was entirely due to the action of the sea, but practically every one of these posts was broken at every hole the bar went through. The fact was very noticeable, and he would like to make the remark in connection with what Mr. Etchells has said about the hole causing a fracture in the post.

**The President (Mr. H. D. Searles-Wood)** said although he had no experience in the concrete posts used in connection with fencing, he happened to live in a part of the suburbs where there are miles of oak park fencing, and the maintenance of the posts was a considerable expense. He did not know whether it was possible to have concrete posts and wooden arris rails with oak pales, but it seemed to be worth the experiment. Another point was what was the best way to fix a hook which takes the strap hinge in a concrete post?

### THE LECTURER'S REPLY.

Answering the remarks of Mr. Pickering as to the use of the triangular posts, the lecturer stated that this was one of the very best and cheapest forms of posts that could be used, but in all his experience he never could get such posts taken up. They were particularly cheap for railway companies. Mr. Pickering had also asked a question about the strength of the posts, saying they had stood a tremendous pull. The post was vertical, and the pull was absolutely horizontal. He (the speaker) had not gone into the question of the cost of harbours all round the kingdom, but he took it there were 24,000 or 25,000 miles of railways in England, so that if 5,000 miles were walled, or otherwise protected, there remained 20,000 miles to be fenced. Roughly, there would be a saving of £4,000,000 to the railway companies in twenty years.

He had not gone into details of the straining posts, but, of course, these had been made specially, and all had six reinforcing rods in them, three on each side opposite the pull of the fence. He had never had any failures. He had also made some very big posts that stood about 8 ft. out of the ground, and about 4 ft. square at the top. These were made for a firm who made electrically welded wire. The posts had to stand the strain of a great many hundred tons. They were put up about two years before the war, 200 ft. apart, with nothing between, and the wire was strained. It was a piece of experimental fence, the posts had remained perfectly horizontal, and when he saw the fence about a year ago it was as good as when it went up. He had also made some fencing for the Port of London Authority for the fencing round the port and docks, and he believed that this had been satisfactory, and had shown a great saving as against wood. As to the Chairman's question about wooden rails, concrete had been used as a start for the main posts, with wooden runners and verticals, because it was the main posts that rotted at the ground, and very often caused the failure of the whole fence where otherwise the fence would have lasted for years. The Chairman had also asked about posts for carrying gates. He (the speaker) had sometimes found a difficulty about that, because the concrete posts could not be arranged as conveniently as wooden ones for chipping and fitting. He had got special double screws for this purpose with a nut on both sides, so that the gates could be adjusted quite accurately. Regarding reinforced concrete fences for sea frontages, this had been done, but special treatment was required owing to the action of the sea water. Regarding the use of bars through the posts, the lecturer said he had known a great many cases of failure for want of proper reinforcement. Reinforcement should be round the holes. He used at one time to put a square disc like a big washer, which acted very well, and did not take up much room in the post. These posts should be more or less constructed for the places where they were to be used. When reinforced, a post can be sent out in three or four weeks, and it will stand the rough usage in transit quite well, but if not reinforced it would probably crack if dropped on the ground. Regarding the minimum size of post that had been made, a great many 3 in. square posts had been made for putting round tennis courts, and for use in pergolas, etc. Such posts might be made 10 in., 12 in., or 15 in. long, they were quite useful for any light work, and were cheap.

## INSTITUTION OF MUNICIPAL COUNTY ENGINEERS.

# CONCRETE ROADS.

At a recent meeting of the Institution of Municipal and County Engineers at Exeter, some interesting views were expressed on reinforced concrete roads. Mr. W. P. Robinson, A.M.Inst.C.E. (County Surveyor, No. 2 Division, Devon), in the course of a paper on the subject of road maintenance, said that provided suitable material was used for the aggregate the surface of concrete roads should not be more slippery than other forms of hard, impervious surfaces under the same conditions of traffic, weather and gradient. The objection to concrete on the grounds of the additional expense of laying or repairing underground pipes, cables, etc., could be overcome to a large extent by ensuring that all existing pipes were placed in thorough repair before the concrete was laid, and that new mains were either laid in culverts provided for the purpose during the construction of the concrete surface or laid outside the width of the road. Apparently the chief deterrent in many cases to the use of concrete road surfaces, he said, was the initial cost, but if the initial cost and the maintenance cost were spread over a period of years he thought that highway authorities might be encouraged to adopt this form of surfacing. In a table of estimated costs, the author showed that on this basis the annual cost of water-bound granite macadam with a life of four years would be £484 per mile over a period of twenty years, whilst the annual cost of a concrete road over the same period would be £440 per mile, a saving in favour of concrete of £44 per mile per annum. With regard to the position of the reinforcement, he recommended: (1) That on stable subsoils where the road-bed could be efficiently drained and steam-rolled and was not likely to be subject to subsidence, the reinforcement should be placed as near the upper surface as the aggregate would permit, but not less than 1 in. below the surface; (2) on unstable subsoils, it should be placed a similar distance from the under face of the concrete; and (3) under certain conditions, such as where there was considerable traction-engine traffic, yielding subsoil or variation in temperature, a double reinforcement might be necessary. The author expressed the opinion that the construction of concrete roads offered a wide field for research and experimental work, particularly with regard to the position and size of reinforcement for various conditions of traffic, subsoil and temperature, the construction and spacing of joints, methods of repair and maintenance, and the most suitable aggregates to ensure foothold for horses.

In the discussion which followed the reading of the paper, Mr. E. Stead (Somerset County Council) mentioned that the Under-Secretary for Public Works of the French Government had recently suggested that even if concrete roads cost twice as much as macadam roads they would still be economical. He (the speaker) agreed that expansion joints could be eliminated. Mr. S. Hutton (Exmouth) stated that in his experience concrete roads were the only ones that remained non-slippery after frosty weather. Mr. G. A. Millard said he was in favour of drains being laid herring-bone fashion across the roads. One advantage of concrete roads, which had been overlooked, was the freedom from trouble experienced with them where roads were liable to be flooded. He did not think that the author's suggestion of 1 in. below the surface for the reinforcement allowed sufficiently for wear. Mr. T. Moulding (Exeter) was also of the opinion that expansion joints were unnecessary in concrete roads. Mr. D. Edwards (Taunton) said that concrete surfaces were known to be non-slippery. In his opinion, if the reinforcement was placed near the surface it would throw the stresses and strains to the bottom.

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### *THE CONCRETE INSTITUTE.*

# THE PRACTICAL APPLICATION OF REINFORCED CONCRETE.

In dealing with this subject before the Concrete Institute last month Dr. Oscar Faber, O.B.E., referred to some methods of handling concrete and placing it in its final position in the building. These methods, he said, resolved themselves principally into three, namely:—(1) Scotch derrick cranes; (2) lift tower carrying concrete trucks or barrows; (3) shute method.

The first is generally employed on English buildings of great size where there are great loads which need lifting anyhow (as in the stonework or steel girders, etc.).

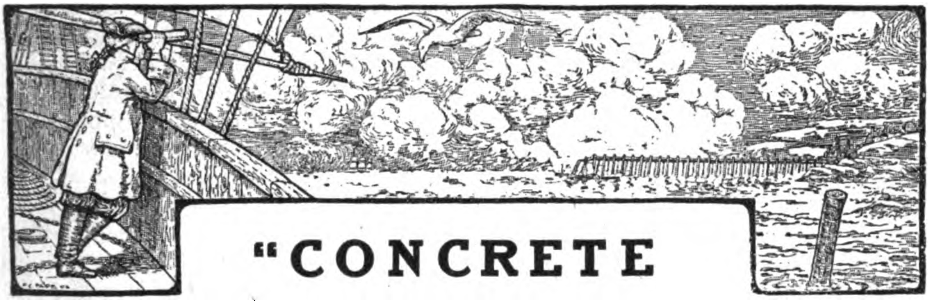
The second is a good method, often used in England, in buildings not having any weights requiring a crane—for example, factories executed entirely in reinforced concrete. The mixer charges the barrows or trucks, which are run on to a lift platform which lifts them to any floor, where they run on to the bay where they are wanted.

The third is the modern American method. In this the tower is much taller than the building. The mixer charges a hopper in the tower, which then rises to the top and discharges automatically into a hopper at the top of the tower, from which it flows down a series of open chutes, hung at an angle of about 1 in 3, and is delivered direct to the work.

This last method obviates two men or more and also removes the necessity of constructing the centering strong enough to carry concrete trucks.

The shutes are generally carried on catenary ropes.

The question of metallic centering was then dealt with and various forms explained, showing how labour is saved by ingenious jointing devices. It is, however, most important that the shutters shall be thick enough to stand rough treatment without becoming dented and twisted, and $\frac{3}{16}$ in. in sheet iron, or less if backed with timber, appears to be necessary. Anything less will be costly owing to its rapidly coming out of commission.



# "CONCRETE SHIPBUILDING"

## REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

### CHAPTER XI.

### THE ADVANTAGES AND LIMITATIONS OF CONCRETE.

So many exaggerated statements have been published by interested or ill-informed persons concerning the advantages and limitations of reinforced concrete in the construction of vessels that it is exceedingly difficult to compile a full yet accurate statement. The following advantages are, however, admitted by all those who are most fully conversant with the subject.

No statistics are needed to show the necessity of conserving all the wood and steel possible, and for building ships of some other material, such as concrete, but quite apart from this the following are some sound and logical reasons why reinforced concrete should be used for this purpose :—

(1) The materials are available in the necessary quantities at almost every accessible part of almost any coast and on most waterways.

(2) The amount of highly skilled labour required is relatively small, and the total amount of labour needed is small.

(3) Concrete vessels can be constructed rapidly when once the necessary moulds or forms have been prepared. These forms can be used repeatedly.

(4) The cost of construction is low, as much of the work is not highly skilled. The costly caulking, heavy form-work, bracing, fitting of plates and shaping of planking are not required in concrete vessels. As the work of casting proceeds rapidly, the dock space required is small in comparison with the output and this effects a further saving.

(5) The amount and cost of repairs and maintenance are low and require no highly skilled labour. Painting is unnecessary, and this alone means a great economy. Barnacles and other sea-growths do not readily adhere to concrete and no corrosion occurs. Wood-boring worms (teredos) and rodents do not attack concrete, so that the cost of scraping and plate renewals is avoided in concrete vessels. A careful examination of two concrete barges used daily in Norway for eight years showed that no growths occur if the surface of the concrete is smoothed before launching.

(6) The properties of reinforced concrete in building other structures are so well known that there is no great difficulty in employing the material in shipbuilding.

(7) The nature of reinforced concrete is such that it is peculiarly resistant to shocks; hence it offers a better resistance to collisions, torpedoes and shells than much of the material at present in use. The reinforcement dissipates the force of an explosion, limiting the possible damage and making it much more difficult to sink a concrete vessel. Reinforced concrete is a material which is peculiarly suitable for building "compartments"—the arrangement now recognised as securing a maximum of safety in vessels at sea.

(8) As concrete does not burn, vessels built of it may be made fire-resisting. The claim that reinforced concrete is fireproof is quite erroneous. It is fire-resisting, and the effect of fire on reinforced concrete is not developed so quickly as it is on steel, and undoubtedly it will carry considerable loads without deformity whilst at a high temperature, which steel will not do.

(9) The plastic nature of the material enables ships of graceful lines to be constructed and removes certain technical limitations in design which are unavoidable in steel ships. There is no jointing as with wood or steel, no rivets or bolts to be loosened by vibration or strains. The absence of angular projections and the ease with which rounded edges and a smooth surface may be produced greatly reduce the skin-friction of concrete vessels, and so facilitate their passage through the water.

(10) The durability of properly made concrete on land is incomparably greater than that of either steel or wood, and there is no reason to suppose that it will be less durable than these materials at sea. Concrete is not subject to dry-rot like wooden vessels or to corrosion like steel ones. There is no reason why vessels made of *properly prepared* concrete should not last for fifty years or more without needing special allowance for depreciation. Inferior concrete will soon perish.

Reinforced concrete vessels for river, canal or harbour work have stood the test of time very well indeed; particulars of such vessels have been given previously. Seacraft, however, are submitted to more severe strains; and though large seafaring vessels built of concrete are too new for extensive data as to their durability to be available, the experience already gained is sufficient to show that there are good grounds for assuming that the reinforced concrete vessels have the necessary lasting qualities.

The effect of sea-water on reinforced concrete has already been referred to.

(11) A further great advantage of concrete vessels lies in the fact that they may be designed so as to resist the whole load when the latter is concentrated in one part instead of being uniformly distributed. To do this in a steel or wooden vessel would require a structure of much greater strength and weight than is needed when reinforced concrete is employed.

The possibility of obtaining a monolithic structure is one of the great advantages of reinforced concrete in shipbuilding, and may be secured by bonding the bulkheads, partitions, floors and decks to the hull and to the main longitudinal and transverse framings, so as to obtain maximum support for every part and maximum distribution of all loads.

A further advantage of reinforced concrete lies in the fact that, whilst ordinary wooden and steel vessels are necessarily designed to carry a uniformly distributed load, a concrete vessel may be designed in the form of a large number of segments, each able in itself to resist the whole load if concentrated at one part, so that the vessel as a whole can be made much stronger than one built of any other material.

There is another feature of concrete vessels which opens up interesting commercial possibilities. Such vessels, with their correct disposition of materials and their largely augmented longitudinal strength, allow an entire reconsideration of the relative dimensions of vessels, as it is possible to add 30 or 40 ft. to the ordinary length of a proposed ship, the breadth and depth remaining as before, and still have a ship much stronger longitudinally and transversely than the shorter vessel would be if built on the ordinary transverse system. The resulting increase of carrying capacity would be effected at a very small cost as the reinforcement of the other dimensions would not be materially altered, and it is quite reasonable to assume that the lengthened vessel fitted with the same engines would steam on the same coal consumption at the same speed as the shorter vessel, and the extra cubic capacity, and all the extra space, would be just where it is wanted, in the middle of the ship. This advantage, which applies to all longitudinally reinforced vessels, including those of the Isherwood system, should prove a very decided attraction to shrewd shipowners, who will have no difficulty in arriving at the extra earnings such a ship would mean to them. By adopting these revised dimensions it is possible, if considered desirable, to fine the ends of the vessels and lose very little of the extra capacity, as the ends of the ship in any case are taken up to a very large extent by the peaks. All this is capable of being verified by investigation, and it is well worth further examination.

A careful investigation has shown that no other material possesses all these advantages; and considering the novelty of the subject and its intense importance, the objections which have been urged against the use of concrete have been remarkably few and unimportant. The most serious one is to the effect that, as concrete without steel has no tensile strength, it would be necessary to use as much steel in concrete ships as in those made wholly of that metal. This objection is based on a misunderstanding of the nature of reinforced concrete and on the manner in which steel is used in other ships. The latter involve an inevitable wastage of steel on account of limitations of constructive details, whereas in reinforced concrete the steel is placed solely where it is required as a reinforcing agent. Moreover, in all-steel vessels a considerable thickness of steel is necessary to make good any loss by corrosion; in concrete vessels no such excess of material is required.

## MEMORANDA.

**A 2,200-ton Chinese-built Concrete Motor Ship.**—A Chinese concrete motor ship recently ran her trial journey. This vessel was built at Tientsin, China, by Brossard et Mopin Cie, and is 270 ft. long, 38 ft. beam, and 18 ft. draught, and is of 2,200 tons deadweight capacity. She will carry general cargo as well as 16 first-class and 12 second-class passengers. The propelling machinery comprises two six-cylinder four-cycle type 500 b.h.p. McIntosh and Seymour Diesel engines. The auxiliaries are two 25 b.h.p. Fairbanks-Morse hot-bulb oil engines for electric light and air compressors, all the rest of the machinery being steam driven by an oil-fired boiler. The fuel tanks are of concrete.

**Concrete Motor Ships Built in Denmark.**—On March 2nd the Codan Shipyard at Kiöge launched its first vessel constructed of concrete. The ship, which is of 1,300 tons deadweight and is equipped with a 400 h.p. Diesel motor, has been built for the Triton Shipping Co., which has a sister ship standing near by almost complete. The cement used cost kr. 25,000, while about 160 tons of steel have been employed. The manager of the Codan Shipyard expressed himself in confident terms regarding the concrete ship.—*Motor Boat.*

**A Concrete House-Boat.**—We learn from the daily press that a concrete house-boat is being built on the Thames and is nearing completion.

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER I.—*continued.*

15. It was mentioned in par. 1, that concrete will stand a crushing strength up to about 2,400 lb. per sq. in.

In practice, we design so that it shall not be stressed to more than 600 lb. per sq. in., because we do not wish our buildings to approach the conditions when failure would occur.

The figure 2,400 lb./in.$^2$ is sometimes called the *ultimate* or *breaking* stress, and 600 lb./in.$^2$ the *safe* or *working* stress, and the ratio

$$\frac{\text{ultimate stress}}{\text{working stress}}$$

is called the *factor of safety.*

Thus, with figures of 2,400 and 600, the factor of safety is

$$\frac{2{,}400}{600}=4$$

Notice, however, that if the 2,400 is the strength in 3 months, the strength in 1 month after mixing the concrete would only be about 1,600, and if the structure, designed for working stresses of 600 lb. per sq. in. is then fully loaded, as may easily occur, the factor of safety at 1 month will only be

$$\frac{1{,}600}{600}=2\tfrac{2}{3}$$

If the structure fails then, it will be no help that it would have been stronger if left longer.

16. Such failure might occur due to any of the following causes :—

(*a*) If the concrete in places is not as strong as it should be, which may be due to bad cement, dirty sand or stone, wrong proportions, concrete disturbed after setting has begun, wood shavings being left in, the effect of frost or low temperature, and many other causes.

(*b*) If the stress is really more than was thought, owing to incorrect calculations, insufficient allowance for loads on floors, etc.

17. It follows that while a factor of safety of 2⅔ may be ample with good construction and good design it may be insufficient if either is bad.

18. The *ultimate stress* of *mild steel* is about 64,000 lb. per sq. in., and the *safe stress* about 16,000 lb. per sq. in.

This gives a *factor of safety* of 4.

19. This does *not* mean that the structure will carry four times as great a load as it was designed for, because, as explained in par. 8, the steel yields badly at about half its ultimate stress. When this occurs, the cracks in the concrete open and become visible to the naked eye.

The relationships on which strength calculations are based are then completely upset, and failure soon occurs.

A reinforced concrete structure designed for a factor of safety of 4 generally stands loading up to twice its designed load without serious cracks, and fails under anywhere between two and three times the designed load.

Roughly, then, if we work to stresses of 600 lb. per sq. in. in the concrete in compression, and 16,000 lb. per sq. in. in the steel in tension, we shall have a nominal factor of safety of four, but a real factor of safety of about 2⅔.

20. Attention is directed to *Fig.* 1, which illustrates some of the points already dealt with in connection with simple beams.

It shows the upper part compressed and the lower part extended, and the line

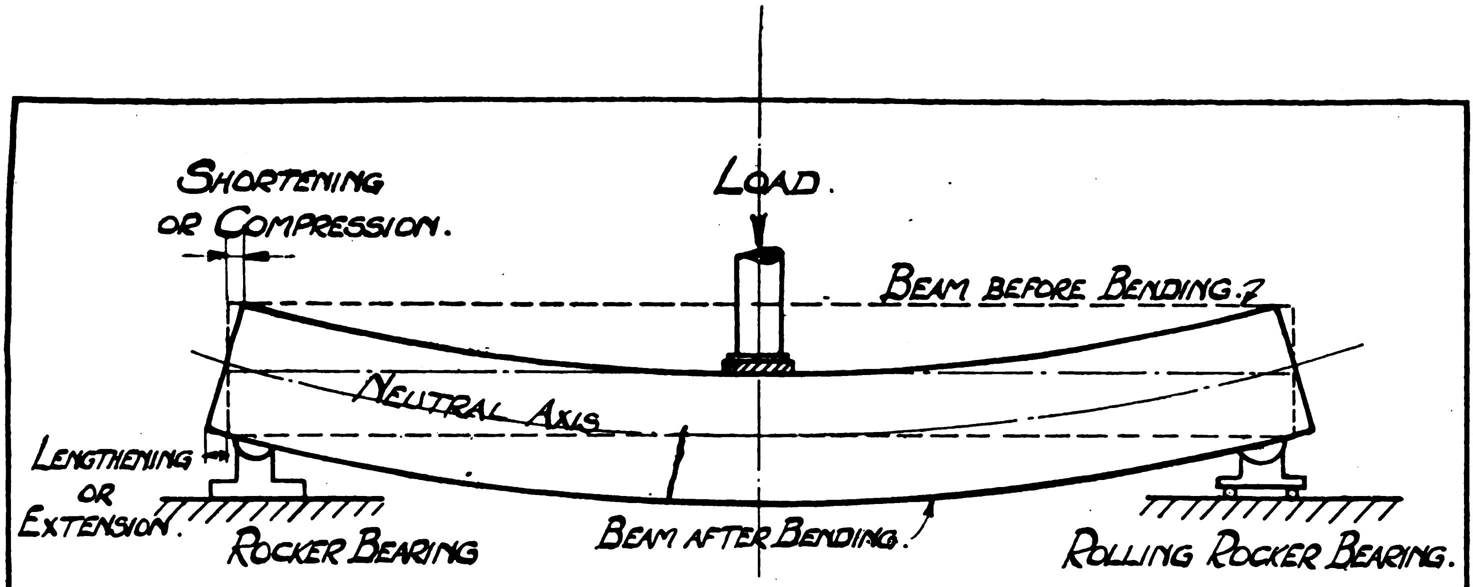


FIG 1. BEAM UNDER SIMPLE BENDING.

SHOWING (1.) THAT THE TOP IS SHORTENED AND THEREFORE IN COMPRESSION
(2) THAT THE BOTTOM IS EXTENDED AND THEREFORE IN TENSION.
(3.) THAT BETWEEN THE TWO IS A LINE, NEITHER EXTENDED NOR COMPRESSED (CALLED THE NEUTRAL AXIS)
(4) THAT THE AMOUNT OF EXTENSION OR COMPRESSION VARIES DIRECTLY AS THE DISTANCE FROM THE NEUTRAL AXIS
(5) THE KIND OF TENSION CRACK WHICH WILL CAUSE FAILURE OF THE BEAM UNLESS REINFORCED.

between the two (called the *neutral axis*) which remains its original length, and is therefore unstressed.

*Fig.* 1 also shows clearly at the ends that the *amount* of the extension or compression varies directly as the distance from the neutral axis.

Combining this fact with Hooke's law (par. 7) it follows that *the compression or tensile stress varies directly as the distance from the neutral axis.*

This is an extremely important result, which we shall use very frequently.

It is for this reason that steel joists are made the shape they are, with most of the metal concentrated at the extreme top and bottom. The metal here, being as far as possible from the neutral axis, is fully stressed, and therefore made full use of, while any metal near the neutral axis is hardly stressed and therefore adds nothing appreciable to the strength, and is therefore reduced to a minimum in joists of economical form.

21. Notice, in passing, on *Fig.* 1 that the supports of the beam occur on the bottom near the end, which extends during the process of loading and bending.

It follows that there is a tendency during loading to push the two supports apart.

Where the supports are relatively flexible, as in the case of reinforced concrete columns in a building of usual proportions, the columns adjust themselves to this without detriment, but in the case of long girders on relatively inflexible piers (as often occurs in large bridges) provision has to be made for this movement by providing a roller bearing at one end and so leaving it free to move as desired.

22. When beams are tested in laboratory experiments, it is very important that provision shall be made for movement.

As a rule, *Rocker Bearings* are provided (as at the left hand end of *Fig.* 1) so that an even bearing is maintained in spite of the deflection and consequent slope at the end. If this were not done, all the weight would come on the inside edge of the supports, and in the case of concrete beams the intense stress would crush the concrete.

Rocker bearings alone, however, are not sufficient, since they do not allow for extension of the bottom of the beam, and unless this is left free to extend as it wishes, the tension is transferred from the bottom of the beam to the beam on the testing machine which connects the two supporting bearings, and the results are then quite misleading.

The writer once made a series of experiments (*a*) with the usual fixed rocker bearings, and (*b*) with *roller bearings*, as in right hand end of *Fig.* 1, and with concrete beams the difference was very marked.

With concrete beams, roller bearings are quite necessary in experimental work.

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

*In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.--ED.*

*Question.—W. G. R. enquires how to arrive at the amount of excess mortar in the following mixtures of concrete. According to diagrams he has they show a certain amount of excess mortar for every mixture.*

| Percentage of voids in Aggregate. | Cement in lbs. | Voids 37% sand in cu. ft. | Aggregate in cu. ft. | Excess Mortar. | Mixture 1—2—4 |
|---|---|---|---|---|---|
| 40% | 540 | 12 | 23·9 | 32 | These figures are according to Diagram. |
| 41% | 545 | 12·1 | 24·15 | 28·5 | |
| 42% | 550 | 12·2 | 24·35 | 25·5 | |

*Answer.*—The diagrams referred to are those published by Mr. T. J. Gueritte in his paper before the Society of Engineers on March 11th, 1918.

The excess mortar is very easily calculated from the other figures given as follows :—

*Case* 1.

| | *Quantities to form 1 cu. yd.* |
|---|---|
| Cement .. .. .. | 540 lb. |
| Sand (37 per cent. voids) .. | 12 cu. ft. |
| Aggregate (40 per cent. voids) | 23·9 |

$$\text{Voids in aggregate} = \frac{40}{100} \times 23{\cdot}9 = 9{\cdot}6 \text{ cu. ft.}$$

Since the volume of concrete is 27 cu. ft. and the aggregate only 23·9, there is clearly enough mortar to fill the voids in the aggregate, and then to leave an excess of 27 − 23·9 = 3·1 cu. ft., which brings the volume of concrete up to 27 cu. ft. (1 cu. yd.).

Hence the percentage excess mortar is

$$\frac{3{\cdot}1}{9{\cdot}6} = 32{\cdot}4 \text{ per cent.}$$

*Case* 2.

Aggregate (41 per cent. voids) to one cu. yd. concrete = 24·15 cu. ft.

∴ Excess mortar = 27 − 24·15 = 2·85 cu. ft.

Voids in aggregate = ·41 × 24·15
= 9·9 cu. ft.

$$\therefore \text{ Percentage excess} = \frac{2{\cdot}85}{9{\cdot}9} = 28{\cdot}7$$

*Case* 3.

Aggregate (42 per cent. voids) to one cu. yd. concrete = 24·35 cu. ft.

∴ Excess mortar = 27 − 24·35 = 2·65 cu. ft.

Voids in aggregate = ·42 × 24·35 = 10·2 cu. ft.

∴ Percentage excess = 26 per cent.

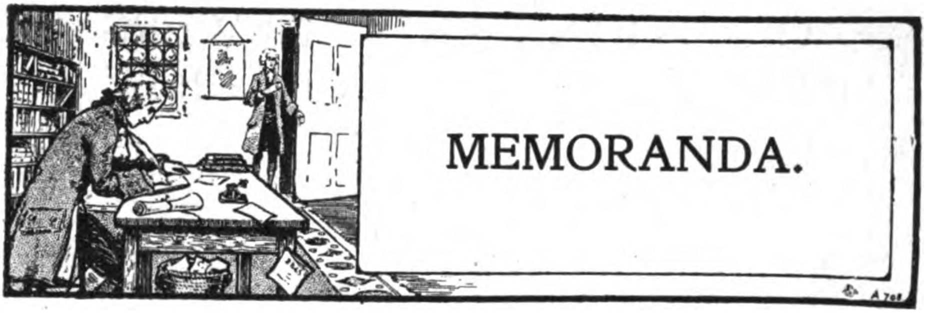
These figures do not agree *exactly* with those given, due no doubt to slight discrepancies either in the drawing of the curves or your reading of them. Clearly the result is very sensitive to the exactness of the volume of aggregate required for 1 cu. yd., since it is the *difference* between this figure and 27 cu. ft. which determines the percentage required.

## MEMORANDUM

**Scientific and Technical Books.**—One part of the Descriptive Catalogue of the British Scientific Products Exhibition, organised by the British Science Guild last year, was devoted to selected lists of books on science and technology.

The Guild has been asked to extend these lists, so as to include not only all branches of science—both biological and physical—but also the chief technical subjects.

The lists will be limited to books of British origin actually in current catalogues. The general standard will be that of college courses in scientific and technical subjects or of works libraries. In order to secure that no important work is omitted, the Committee invites the assistance of everyone interested in its task. Such aid may be afforded by sending (to the British Science Guild, 6, John Street, Adelphi, London, W.C.2), lists or single titles of British books of standard value or proved worth in any branch of science or industry.



*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**The Building Trades Exhibition.**—We would draw the attention of our readers to the Building Trade Exhibition which is being resumed this year after, like so many other annual events, being suspended during the war. This year's Exhibition, which is to be held at Olympia from the 10th to the 24th of this month, should be of special interest owing to the strides made in building during the past five years. In fact, the improvements in building construction, especially concrete construction, and the many new inventions which have been adopted in small house and cottage building to relieve the housing shortage, provide an opportunity for this show to surpass all those which have preceded it. Among the stands in the body of the hall which should be specially attractive to those interested in concrete, are those of Messrs. Kerner-Greenwood & Co., Ltd.; The Ruberoid Co., Ltd.; Associated Portland Cement Manufacturers (1900), Ltd.; Ransome vehr-Mehr Machinery Co., Ltd.; Johnson's Reinforced Concrete Engineering Co., Ltd.; the Expanded Metal Co., Ltd.; Sharp, Jones & Co. Winget, Ltd.; the Concrete Utilities Bureau; The British Fibrocement Works; D. Anderson & Son, Ltd.; the "Interoven" Stove Co., Ltd.; Stothert & Pitt, Ltd.; The Torbay and Dart Paint Co., Ltd.; Vickers, Ltd.; British Steel Piling Co.; the Waller Housing Corporation; Concrete Dwellings, Ltd.; the Ironite Co.; J. A. King & Co.; and Mr. H. Maberley Smith, F.R.I.B.A.

The Concrete Institute will pay an official visit to the Exhibition on Wednesday, April 21st.

Visitors to the Exhibition will find it worth their while to pay a visit to the Permanent Exhibition of Concrete Products arranged by the Concrete Utilities Bureau, of 35, Great St. Helens, at 143, Grosvenor Road, S.W.

**Shop Fronts.**—A paper was recently read before the Institute of British Decorators by Mr. Arthur Wilcock, Fellow of the Institute, dealing with the art of shop-front designing, and touching upon the question of construction the author made the following remarks :—

" The coming of reinforced concrete and steel construction has been of the greatest advantage to the shopkeepers. The principles which govern this form of building are wholly different from those which obtain in the brick and stone construction of the Classic and Gothic styles; we have therefore to readjust our ideas to accord with these new principles.

" With this construction very wide spaces can be bridged with narrow piers, so giving the maximum amount of window space.

" Naturally, a brick or stone building running up to five or six floors, if it is to appear well supported, will sometimes admit of nothing but supporting columns. Even solid masonry, with little or no window space for the shopkeeper on the ground floor, would only appear adequate support for some superstructures from the point of architectural view of stability. It is no delight, and even a source of much unrest, to look upon a structure that appears to have no base or support, or supported only on sheet glass. To overcome this, while and if architects still persist in building on Classic lines, massive supporting columns may be run down to the ground and the shop front recessed.

"One would have thought that with the advent of such a revolutionary structural method as 'reinforced concrete,' architects with any powers of invention would have discarded such Classic styles as used for building temples, and set to work to create a new style of building for big shopping emporiums. The possibilities are there, and with the architect I leave this subject of construction."

## HOUSING NOTES.

**Standard Specification for Cottages.**—In the specification recently issued by the Ministry of Health for the building of cottages no mention was made of concrete mixers and upon enquiring whether they would approve the use of such machines for building purposes, we learned that the Ministry of Health raises no objection to the use of concrete mixers, providing the concrete is used immediately it comes away from such mixers.

**Manchester.**—The Manchester Housing Committee have decided to build twenty reinforced concrete houses on the Newton Heath estate.

**Bolton.**—The Bolton Corporation propose erecting 32 concrete houses on the Dorman Long system at £900 per house. The houses will be those specified by the Housing Committee as type "B," containing three bedrooms and a parlour.

**Cheshire.**—The Arclid Rural Council has decided to erect 100 concrete houses in various townships at a cost of £650 per house.

**Large Scheme at Bristol.**—The Housing Committee has reported to the Bristol Town Council that it hopes to undertake the erection of 1,500 houses this year, including 500 of concrete construction. After considering the limited amount of labour available for the erection of brick houses, the Committee had a conference with the Ministry of Health, and found it advisable to consider other methods of construction. It therefore proposes, subject to the satisfactory arrangement of terms, to let contracts to Messrs. W. Cowlin & Son, the Waller Construction Company, and Messrs. R. Wilkins & Sons, to erect houses by various systems of concrete construction. Subject to the modifications required by these contractors, the elevations and plans will conform to those of the brick houses.

**Aberdare.**—1,200 concrete houses are to be built at Aberdare.

**Poured-Concrete Houses.**—The "Ingersoll" system of poured-concrete house construction was further advanced during the past year, a six-room house having been erected at Phillipsburgh, New Jersey, U.S.A. This house is designed to sell at $3,250. It is claimed that an experienced gang of eleven men can erect the shuttering and pour the concrete at the rate of five days per house. All the constructional details are standardised. After the forms have been removed, the walls are covered with two coats of stucco applied with brushes. This operation takes three men two days to perform, and 1,500 lb. of stucco per house are used.

**Solid Concrete Walls Built in Situ.**—The Ministry of Health in a recent number of *Housing* published the following specification for concrete walls:—

*Cement.*—The cement is to be Portland, of slow-setting quality, and is to comply with the requirements of the current specification of the British Engineering Standards Committee.

*Ballast Aggregate.*—The ballast is to be granite, hardstone or gravel, broken to various graded sizes, the largest to pass a 1 in. square mesh and sufficient clean sharp sand, free from salt, is to be added to fill the interstices.

*Reinforcement.*—Steel cannot be accepted as a reinforcement in concrete made with clinker.

*Clinker Aggregate.*—The clinker must be dense, vitreous, free from organic and combustible matter and crushed to pass a ½ in. square mesh and be well washed and screened before use. A proportion of clean, sharp sand, not less than 5 per cent. and not more than 10 per cent., is to be added. Coke breeze will not be allowed.

*Composition.*—The concrete is to be composed by measure of not more than six parts of aggregate to one part of cement.

*Mixing.*—The concrete is to be mixed on a clean platform, made either of wood or concrete, and turned over dry with a rake and shovel until the colour of the cement is evenly distributed through the aggregate.

When thoroughly mixed dry it is to be again turned over with a due proportion of water applied through a rose to work it to a sufficiently wet consistency, so that if a handful is taken from the heap and pressed, it will retain its shape when the pressure is removed.

Not more than 20 per cent. of water by measure shall be used in mixing clinker concrete.

A mechanical mixer may be employed if no more concrete is made at one time than is required for immediate use.

No concrete, in which the initial set of the cement has taken place, shall be used for building walls.

*Thickness of Walls.*—External and party walls of the same composition of concrete throughout shall be not less than 8 in. thick, and internal partition wall not less than 3 in. thick. If the external wall is built partly of ballast concrete and partly of clinker concrete, the inner part of clinker concrete shall be not less than 2 in. thick and the outer part of ballast concrete not less than 4 in. thick, but the total thickness of the wall shall not be less than 8 in.

Where the wall is encased between properly prepared and compressed sheets of asbestos not less than ¼ in. thick, or other approved material, the thickness of the wall may be reduced to 6 in.; but a projecting corbel course of sufficient strength must be provided to carry the wood joists, or other forms of floor construction, for the upper floor. Where the wall is provided with a continuous efficient vertical damp course in the centre of the wall the thickness may be reduced to 6 in., but the two halves of the wall must be tied together with suitable wall ties every 18 in. in height, the ties to be spaced not farther apart than 18 in.

*Building of Walls.*—The concrete is to be placed between the forms or shutterings in layers of not more than 18 in. high at a time, carried evenly round the building in horizontal layers and is to be thoroughly well rammed.

No raking joints can be allowed.

Before the next layer is placed, a thick grout of three parts of sand to one part of cement is to be poured over the layer previously rammed.

The forms or shutterings are to be kept clean, and are to be removed before the concrete has hardened, in order that the surfaces may be scored for external rendering and internal plastering.

*Finishing.*—All concrete walls shall be finished internally with an absorbent plaster.

All clinker concrete walls shall be rendered and finished externally in cement rough-cast.

Where the forms or shuttering permit of a smooth external face to ballast concrete walls, these can be finished in durable distemper without cement rendering.

## NEW METHODS AND MATERIALS.

The following is a list of materials and new methods of construction approved by the Standardisation and Construction Committee since our last issue :—

*The Economic Building Corporation, Economic Buildings,* 323, *High Holborn, W.C.*1.—A system of concrete construction with slabs 2 in. thick strengthened with lugs in the centre of each slab—two slabs forming a cavity wall 6 in. thick, the lugs interlocking in the centre and tied together with suitable ties.

*The Tourba Construction Co., Ltd.,* 42, 43, 44 *and* 60, *Terminus Chambers,* 6, *Holborn Viaduct, London, E.C.*1.—A system of concrete construction the stanchions being reinforced with T or L irons and the outer skin of the cavity wall with expanded metal, and as submitted is approved for the construction of the ground floor only.

*The Ingersoll-Rand Company,* 165, *Queen Victoria Street, London, E.C.*4 (*Agents for the "Cement Gun"*).—*The "Cement Gun."*—A mechanical device largely used in America for coating the exterior of a building, girders, stanchions, etc., with hydrated concrete to any thickness that may be required, finished with either a smooth or rough-cast face.

*The Australia Concrete Block Co.,* 92, *Victoria Street, Westminster, S.W.*1.—The Australia Concrete Block Company's machine is for the manufacture of semi-dry concrete blocks.

*E. Swingler,* 5, *Bridge Street, Leighton Buzzard.*—A form of concrete construction with slabs 3 in. thick and a wall cavity of 3 in. The inner and outer thicknesses of the wall are tied together at every vertical joint by specially shaped blocks which form a dovetail connection with the inner and outer slabs, the joint being grouted in cement.

*E. McKaig, A.M.Inst.C.E., Edendale, Weston-super-Mare.*—"*Auto Bond Building Blocks.*"—A system of concrete construction with blocks 3 in. thick and a wall cavity of 3 in., with a dovetail section horizontal bonding course alternating with the slabs, which locks the slabs into their correct position in the wall. The horizontal bonding blocks are perforated to form a continuous air cavity and to allow condensed moisture to be dispersed.

*W. A. de Kavanagh*, 34, *Aynhoe Road, Brook Green, London, W.*—A proposal for using concrete blocks made under hydraulic pressure immediately after they are removed from the machine. The Ministry having received results of tests made to ascertain the shrinkage that would ultimately occur in blocks so used, and having found it negligible, approve the proposal.

*Messrs. Thornley, Mott & Vines, Ltd.*, 11, *Old Queen Street, Westminster, S.W.*1.—*Aero Blocks.*—The Aero Block has two or more rows of air spaces with dividing walls and webs so arranged as to form a continuous air cavity throughout the wall when built.

*Messrs. J. H. & W. C. Mangan*, 18, *Guildhall Street, Preston. Agents for J. Parkinson & Sons, Ltd.*—*J. Parkinson & Sons' (Blackpool) System of Construction.*—This is a system of concrete construction with reinforced stancheons and beams, the spaces between being filled in with slabs so as to form a cavity wall.

*W. Hamilton, Albert House, Henley-on-Thames.*—A system of concrete *in situ* walling having a cavity which is filled with a pre-cast vertical damp course, which is built up stage by stage as the concrete is filled in.

*C. Giles*, 28, *Gray's Road, Henley-on-Thames.*—A system of concrete *in situ* walling in which a cavity is formed as the work proceeds, the core being drawn and the space being filled with a poured vertical damp course.

*F. A. Brown*, 46, *Alma Vale Road, Clifton, Bristol.*—*Concrete Blocks.*—These blocks are made of ballast concrete with a dovetail shaped groove on the inside face into which a concrete dovetail is fixed and grouted, thus forming a cavity wall.

*A. H. Attwater*, 38, *King William Street, London, E.C.*4.—*Concrete Blocks.*—The blocks are made of clinker, sand and cement, having two connecting concrete ties cast on, forming a hollow concrete block, with vertical and horizontal air space.

## TRADE NOTES.

**The Cement Marketing Co., Ltd.**—During the war the production of cement was reduced to about one-half of the pre-war output. Since the declaration of the armistice manufacturers throughout the country have been endeavouring to increase their production to the maximum, but owing to the shortage of experienced labour, suitable fuel and materials for repairs, the full output has not yet been attained. Further, owing to the shortage of means of transport there has been a serious dislocation of the work of distribution and at times it has been difficult to keep works open owing to the accumulation of stocks which could not be distributed to the consumer. The experience of these difficult times has convinced the boards of The Associated Portland Cement Manufacturers, Ltd., The British Portland Cement Manufacturers, Ltd., Martin Earle and Co., Ltd., and the Wouldham Cement Co., Ltd., that increased efficiency in the distribution of the cement manufactured by them would be effected by the consolidation of their selling and distributing organisations. To effect this consolidation the Cement Marketing Co., Ltd., has been formed, which company will solely undertake the selling and distribution of the cement, lime and other goods manufactured and produced by the companies above named.

It is hoped that the fact of the allocation of railway trucks, motor lorries and vans, the management of the various companies' large fleet of barges and lighters, and the chartering of vessels being under one central control will enable the new company to lessen, if not overcome, the difficulties now existing in connection with the distribution of cement and to see that the interests of the various buyers receive equitable treatment. This rearrangement of selling methods is entirely a matter of internal organisation, and has no bearing whatever on the question of prices. The directorate and staff of the Cement Marketing Co., Ltd., will consist of those hitherto handling the output of the above companies, so that a continuity of touch with old customers is guaranteed.

All orders and enquiries should be sent to The Cement Marketing Co., Ltd., at 8, Lloyds Avenue, E.C.3.

**State-Aided Housing and the Winget System.**—With the object of simplifying matters and securing not only despatch and economy in the erection of houses, but also an equitable arrangement on all sides, Messrs. Winget Limited have prepared a special scheme which they suggest is a fair working arrangement between the owners of the houses and the contractors employed in erecting them. Full particulars of the scheme have been published in pamphlet form, obtainable from the above company at their offices, 24, Grosvenor Gardens, Westminster, S.W.

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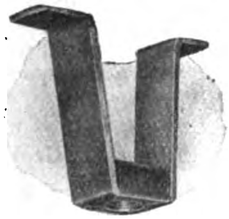
**"Rigifix" Bolt Hanger Sockets and Slotted Inserts.**—Messrs. Building Products, Ltd., have sent us particulars regarding some of their specialities, including their special fittings for concrete buildings. It is claimed for these fittings, known as "Rigifix," that all cutting of finished concrete can be avoided by their use. Cutting into finished concrete work is destructive and expensive, and how best to prevent this is a matter for consideration, before, not after, the building is erected.



These fittings are useful in connecting to concrete work the following: hangers for heating and plumbing pipes and sprinkler systems, supports for electric fittings, cables, conduits, etc., etc. They can be embedded in floor slabs, beams, columns and walls, and should be fixed to the timber falsework or centering before the concrete is poured. This can best be done by means of temporary bolts let into the centering at the points where the fittings are to be set. The temporary bolts are removed when the concrete has become hard. Bolting them to the centering prevents their being shifted when the reinforcement is placed in position and when the concrete is poured.

**Bareau.**—The same firm have also put a new waterproofing material on the market known as "Bareau." For full particulars regarding their various specialities apply to Building Products, Ltd., of 44-46, King's Road, Chelsea, S.W.

**A New Form of Concrete Block Construction.**—A new system known as the "Triangular" concrete block construction has been put forward by Major W. G. Smith, of Imber Court Works, Thames Ditton.

The blocks are all of isosceles triangular shape. Those on the exterior have a hard, impervious face composed of ballast concrete to stand the weather, and those on the interior face are composed of breeze concrete to prevent condensation of moisture and for fixing joinery without requiring fillets or blocks.

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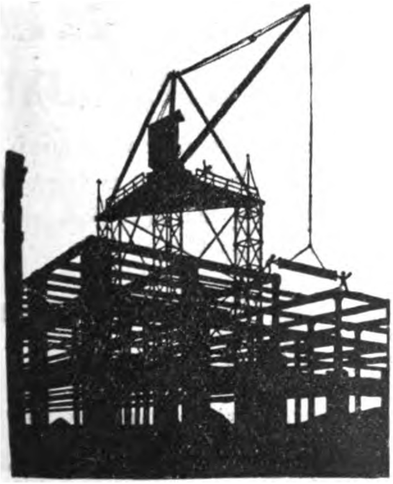


These blocks when built together are said to give a perfect bond of the diagonal type between the two classes of blocks employed, giving maximum strength with the materials involved; the hollow spaces give a free passage of air from the ventilated blocks resting upon the damp-proof course up to the wall head, thus nullifying changes of temperature. By reason of the shape of the blocks it is possible to line up absolutely true both the exterior and interior faces of walls, any variation in size of blocks being made up for in the thickness of the grouting forming the joints. Corbelled blocks are made to form the cornice of the first floor and serve for carrying the floor joists.

Lintels are made of reinforced concrete, so that there is no metal exposed to the air in the whole building. Chimneys are formed of blocks made with a flue space.

Machines are made for manufacturing the blocks.

### CHANGE OF ADDRESS.

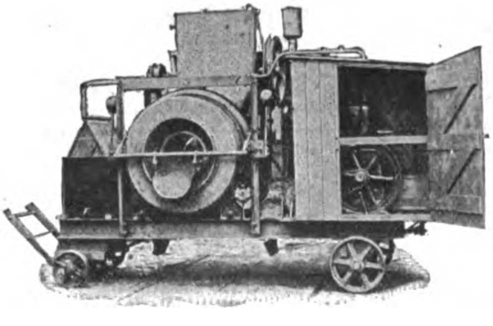
**Messrs. Williams Structures, Ltd.**, have removed their offices to 5, St. George's Road, S.W.1. Telephone: Victoria 7030.

### NEW COMPANY REGISTERED.

A. Kelway-Bamber Linocrete Co., Ltd. (164,988).—Registered March 9th. Manufacturers of "Linocrete." Nominal capital, £5,000 in 4,000 preference shares of £1 each and 4,000 ordinary shares of 5s. each. Directors: A. K. Bamber, 32, Belmont Hill, S.E.; K. W. Gibson, 30, Woodland Villas, N.10; W. H. Weeks, 81, Belmont Hill, S.E.; and W. H. Dunn, 57, Lodge Road, Croydon. Qualification of directors, £50; remuneration of directors to be voted by company.

### RECENT PATENT APPLICATIONS.

No. 138,159.—G. Coe: Concrete and other wall construction.
No. 138,161.—J. S. Baines: Slab wall and fence construction.
No. 138,182.—J. F. J. Peeters: Multiple roofing.
No. 138,415.—G. R. Speaker: Methods of building construction.
No. 138,420.—G. Hutchinson: Girders and columns.
No. 138,569.—J. H. W. Waller: Reinforced-concrete slab roof construction.
No. 138,669.—W. G. Cook: Concrete slab walling.
No. 138,697.—G. Hutchinson: Girders and columns.
No. 138,702.—D. Lewes: Reinforced concrete buildings.
No. 138,716.—H. L. Barraclough: Concrete floors.



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MAY 1920. VOL. XV. No. 5.

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*ISSUED MONTHLY*

## CONTENTS.

Editorials.

The Water Supply of Seccondee, Gold Coast.
By THE CONSULTING ENGINEERS.

Concrete Cottage Construction.
Houses at Liverpool and Coventry.

Concrete Roads.
By EDWIN TOMLIN.

The Building Trades' Exhibition.

Bridge Construction in Reinforced Concrete.
By Prof. E. R. MATTHEWS, Assoc.M Inst.C.E., &c.

Concrete Shipbuilding.
By Dr. A. B. SEARLE.

German Fire Tests on Reinforced Concrete Houses.
By Dr. ARTHUR HOLMES, D.Sc., A.R.C.S., F.G.S.

Recent Views on Concrete and Reinforced Concrete.
The Steelwork in the New London County Hall. By E LAWRENCE HALL.

Concrete in Theory and Practice.
Reinforced Concrete Simply Explained. By OSCAR FABER, O.B.E., D.Sc.

The Foreign Press. Memoranda.

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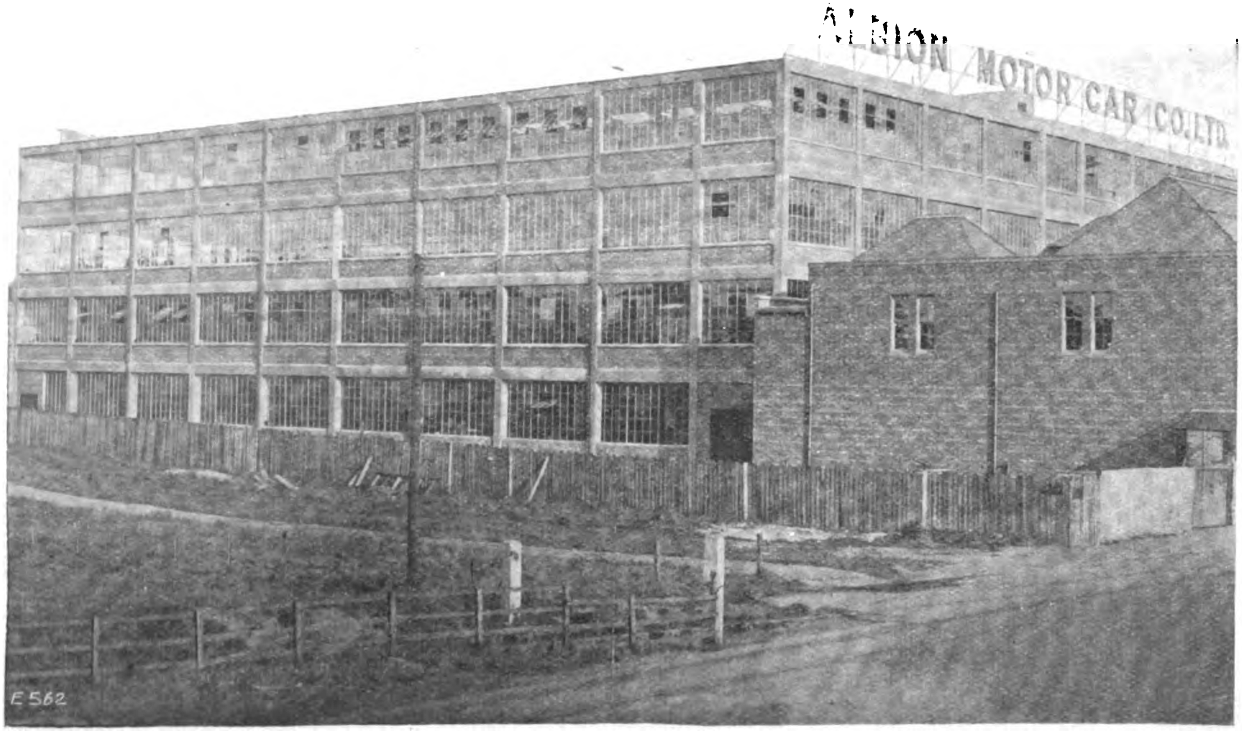


A FACTORY IN SCOTLAND ERECTED IN REINFORCED CONCRETE CONSTRUCTION
(See page 366.)

# CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XV. No. 5. LONDON, MAY, 1920.

# *EDITORIAL NOTES.*

## THE BUILDING TRADES EXHIBITION.

EXACTLY a quarter of a century has elapsed, so we were informed in the foreword to the official catalogue of the Building Trades Exhibition—a volume whose size will soon compete with that of the London Telephone Directory—since the first Building Exhibition, arranged by Mr. H. Greville Montgomery, was held at the Royal Agricultural Hall. In 1907 the *locale* was transferred to Olympia, and the affair was organised on a regular biennial basis until 1913, when the outbreak of war in the subsequent year rudely broke this ordered sequence of events.

The exhibition has for many years been a recognised method of stimulating trade. On the one hand we have international gatherings, such as the Great Exhibition held in Hyde Park in 1851, or the World's Fair at Chicago in 1893, both of which were surpassed in size and importance—but possibly not in magnificence of building—by the Paris Exhibition of 1900, and on the other hand we have the Trade and Technical Exhibition. The function of the first is to stimulate international trade, to find new markets for the exchange of commodities, while the function of the second is rather to bring together the manufacturer and the public, and to afford the latter an opportunity of seeing, all properly arranged for their benefit, different makes of the same article, so that they may compare and select that which is most suitable for their particular purpose.

It would indeed be strange if the great events that have occurred in the seven-year interval between the fifth and sixth Building Exhibition had failed to show their effect upon the first post-war display. The recent exhibition was distinguished from its predecessors in a variety of ways, some of them, indeed, being rather in the nature of things felt than of things seen ; a tone of earnestness reflecting the seriousness of the times and indicative of an endeavour to make up the lost years, to recover ground. The exhibits themselves dealt wth essentials rather than with embellishments, as if to indicate that this is not the occasion for luxury and extravagance in building, such things being more befitted to a nation enjoying the prosperity of a prolonged period of peace than to one just recovering from the greatest struggle in its history.

Many of the exhibits testified to the death of pre-war prejudices. Owing to the scarcity and high price of labour, mechanical aids to building are being developed and accepted, whereas a few years ago such things were viewed with suspicion alike by architect, contractor, and operative, each having his particular reason for adopting an obstructive attitude. Similarly, substitute materials were not regarded with much favour, and they were used only where the necessity for rigorous economy rendered them desirable. During and since the war, however, many of the hitherto considered essential materials have been well-nigh unobtainable, and substitutes have been found for them all. Indeed, it may be said that, with the exception of steel and Portland cement, there is scarcely a material for which some substitute is not to be found. And inventiveness, not merely content with the replacement of scarce materials, produces new methods of construction, and many stalls were devoted to a display of fragmentary dwellings, erected to demonstrate the suitability of some patent constructive system.

### THE DEVELOPMENT OF CONCRETE CONSTRUCTION.

The most startling development, however, that contributed most emphatically to the particular tone of the recent exhibition, was the enormous development of concrete. Regarded, as it was by so many architects before the war, as a distinctly engineer's or surveyor's material; a material for bridges and water-towers, for retaining-walls and silos, but only on the rarest occasions for domestic work—except where hidden beneath the ground—it now flourishes on every side, so that it should seem that there is scarcely a use to which this versatile material cannot be put. Walls, floors, roofs, door and window frames, staircases, man-holes, sewers, fencing posts, all can be made from this ubiquitous mixture. As the natural outcome of this expansion of the use of concrete—an expansion that was urged with sufficient insistency before the war, by those who realised the possibilities of development, and who were neither afraid nor ashamed of it—there were many stalls devoted to appliances connected with concrete. The number of block-making machines is ever on the increase, various forms of shuttering for the construction of *in situ* walls, various methods of reinforcement, of machines for crushing aggregate, for mixing, for casting. Many of them were brought together for the first time, enabling a contractor who wished to keep abreast with the times to equip himself in the most up-to-date fashion, and enabling the architect to specify for the particular material whose merits he has had a proper opportunity of investigating. And thus, indeed, the trade exhibition fulfils its most important function, that of enabling the visitor to see, compare, examine, and finally to select.

### THE HOUSING QUESTION.

Another great change which has taken place since the exhibition of 1913, and which could not fail to make its impress on the recent gathering, was in the matter of housing, for during the intervening period this subject has been lifted from its ertswhile position of comparative obscurity to one of supreme national importance, and the full effect of this is at present far from realised. Already other countries have expressed in unmistakable terms their admiration at the breadth, the courage, and even the *expedition*, which this country has brought to bear on the housing problem, and it is good to remember that while we may fret and criticise at what appears to be slow progress in the making good of the great deficiency of houses, other countries are envious of that very progress which we ourselves despise. But although housing matters occupied an important position, they were not permitted unduly to predominate, and other building interests were by no means neglected. Everything, indeed, was there in the way of plant, materials and equipment that might tend to restore the building industry to its proper position of importance in national affairs. The disturbing effects of a great war do not cease with the signing of peace, but everything that tends towards the promotion of a better understanding between architects, contractors, manufacturers, and the general public, tends, also, to establish a firmer basis, without which progress is difficult. And of the available means for promoting such an understanding, few are more likely to achieve success than the organisation of a thoroughly representative exhibition.

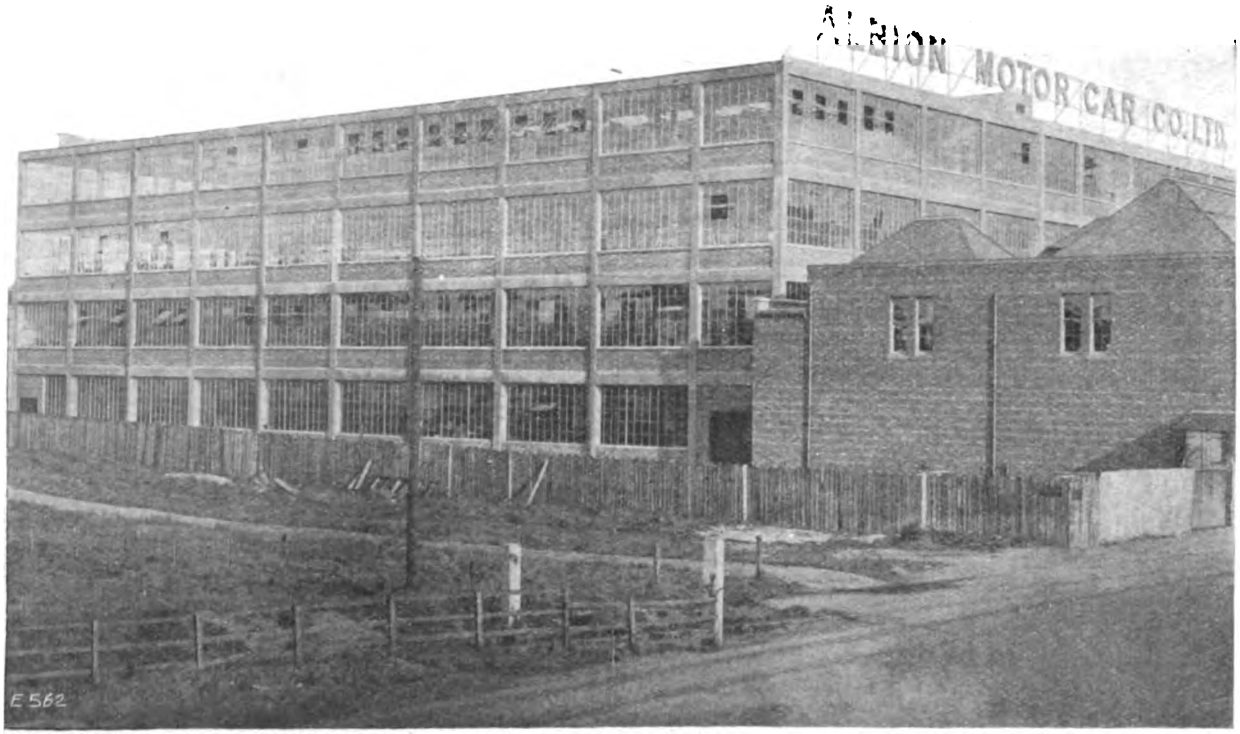
## THE FUTURE OF CONCRETE.

In referring to the Building Trades' Exhibition we have just mentioned the great development of concrete which has taken place since the last Exhibition was held. It may not be out of place, therefore, to indicate briefly what may be the most likely developments in the use of the material in the near future, if we view the question in the light of the experience of the immediate past. The manufacture and use of pre-cast units will undoubtedly be one of the features of the development, and the use of machinery will play an important part in enabling such units to be made in large quantities with the minimum labour and expense.

In connection with the numerous houses to be erected there will be many small features that can profitably be made of concrete, and a large business can be worked up by the manufacturer who is able to offer a variety of concrete frames, posts, slabs, blocks, tiles, pipes, and other similar articles for which there will be a large demand. There are tremendous possibilities in this direction, and the importance of the industry cannot be overrated. The use of larger pre-cast units will also have increased because this class of construction has many advantages which have now been recognised, and considerable experience was gained during the war, when quick erection was necessary.

All types of walling blocks will be in great demand, especially in those districts where bricks are not plentiful and concrete houses are adopted, while the removal of the restrictions imposed by obsolete by-laws will result in the use of concrete walls for all classes of work. Timber is likely to be scarce and expensive for many years, and apart from its obvious advantages, concrete will be called upon as a substitute for the greater part of the work wherein timber was employed in the past.

Reinforced concrete for large structures and engineering works generally will naturally continue to develop rapidly, as this type of construction has long passed the experimental stage, and is now a universal method employed on account of its durability, economy and fire resistance. Practically every contractor in the country to-day is called upon to carry out schemes in this material, and the rapid progress in the past is sufficient evidence of the importance of concrete construction and the need for keeping up to date and being prepared to cope with this class of work. The acquisition of good and sufficient plant and machinery will enable the contractor to compete favourably as regards price when tendering for schemes in competition, and the speedy execution of the work will result in lower establishment charges and give satisfaction to the building owner. There is a marked tendency to increase the use of concrete in railway and road construction, and the near future is likely to see some important developments in this direction.



A FACTORY IN SCOTLAND ERECTED IN REINFORCED CONCRETE CONSTRUCTION

*(See page 366.)*

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XV. No. 5. LONDON, MAY, 1920.

# EDITORIAL NOTES.

## THE BUILDING TRADES EXHIBITION.

EXACTLY a quarter of a century has elapsed, so we were informed in the foreword to the official catalogue of the Building Trades Exhibition—a volume whose size will soon compete with that of the London Telephone Directory—since the first Building Exhibition, arranged by Mr. H. Greville Montgomery, was held at the Royal Agricultural Hall. In 1907 the *locale* was transferred to Olympia, and the affair was organised on a regular biennial basis until 1913, when the outbreak of war in the subsequent year rudely broke this ordered sequence of events.

The exhibition has for many years been a recognised method of stimulating trade. On the one hand we have international gatherings, such as the Great Exhibition held in Hyde Park in 1851, or the World's Fair at Chicago in 1893, both of which were surpassed in size and importance—but possibly not in magnificence of building—by the Paris Exhibition of 1900, and on the other hand we have the Trade and Technical Exhibition. The function of the first is to stimulate international trade, to find new markets for the exchange of commodities, while the function of the second is rather to bring together the manufacturer and the public, and to afford the latter an opportunity of seeing, all properly arranged for their benefit, different makes of the same article, so that they may compare and select that which is most suitable for their particular purpose.

It would indeed be strange if the great events that have occurred in the seven-year interval between the fifth and sixth Building Exhibition had failed to show their effect upon the first post-war display. The recent exhibition was distinguished from its predecessors in a variety of ways, some of them, indeed, being rather in the nature of things felt than of things seen ; a tone of earnestness reflecting the seriousness of the times and indicative of an endeavour to make up the lost years, to recover ground. The exhibits themselves dealt wth essentials rather than with embellishments, as if to indicate that this is not the occasion for luxury and extravagance in building, such things being more befitted to a nation enjoying the prosperity of a prolonged period of peace than to one just recovering from the greatest struggle in its history.

Many of the exhibits testified to the death of pre-war prejudices. Owing to the scarcity and high price of labour, mechanical aids to building are being developed and accepted, whereas a few years ago such things were viewed with suspicion alike by architect, contractor, and operative, each having his particular reason for adopting an obstructive attitude. Similarly, substitute materials

## RECENT NOTES ON CONCRETE SHIPS.

As showing the widely contradictory statements which have recently been published with regard to concrete ships, we may mention that the New York *Journal of Commerce* has reported that no more concrete ships are to be built in the United States as they are too costly to build and require too much power to drive them. As an example, the *John A. Hooper* is mentioned as " an ordinary steamer " of the same length and breadth but 10 ft. less depth than the concrete vessel *Faith*, both these vessels having the same capacity, but the former has a speed of 11 knots under 1,500 h.p. whilst the *Faith* only attains a speed of 9 knots with 1,800 h.p.

From Norway, on the contrary, the captains of four concrete vessels which have, for more than a year, been in continual use in the North Sea, report that they are perfectly dry and free from all seepage, that they are quite strong, weather the foulest seas well, though they tend to ship more water than is necessary on account of the unusually low freeboard. They report that for coal and minerals, these vessels appear to be entirely satisfactory.

The strength of the concrete vessels is shown by the case of the *Askelad*, which was grounded off St. Quentin but was able to release herself by means of her own engines without any damage. This vessel was built of ordinary concrete, but if the light-weight aggregate now available had been used the vessels would have been much lighter and a higher free board could easily be obtained. A concrete barge of 150 tons dead weight capacity has been in use by a Stockholm firm all through the winter and has frequently had to cut its way through ice nearly 9 in. thick, yet when recently examined it was found not to have been damaged.

Two considerable advantages of concrete vessels are easily overlooked: they are—the much smaller amount of vibration experienced by passengers owing to the truly monolithic structure of the ship and the ease with which repairs can be effected under unfavourable conditions. The latter is of special importance in connection with vessels doing a coastal trade in semi-civilised countries or in lands a long way from those in which extensive repairs to ships can be readily made. No structures of equal size can so readily be repaired without the aid of highly skilled men as can a concrete structure, so that for many purposes this advantage more than compensates for some of the relatively small drawbacks which concrete vessels possess.

It has never been contemplated—except by visionaries of greater enthusiasm than practical knowledge—that concrete vessels would be preferable to those made of steel for the work done by the great ocean greyhounds, but there is enormous scope for concrete in the construction of lesser, yet still large, vessels which do a rougher trade under far from favourable conditions, where a little extra weight is of smaller importance than ready repairs and where a little extra power does not matter so much as rapidity and cheapness of construction and durability with a minimum cost of upkeep.

In short, the consideration of the value or otherwise of vessels made of concrete cannot be confined to any one factor, but involves several, and it is clearly unfair to seek to prejudice the issue of the progress of a comparatively new industry by the publication of only part of the facts relating to vessels of this material.

# THE WATER SUPPLY OF SECCONDEE, GOLD COAST.

By THE CONSULTING ENGINEERS.

*The following article gives some interesting information of the use of concrete in connection with the water supply of Seccondee, Gold Coast.—ED.*

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THE Gold Coast Colony, which extends over 300 miles along the Gulf of Guinea, came under the Government of the British Crown between 70 and 80 years ago. In the year 1916 the revenue of the Colony was £1,836,000 and the exports of that year were just over £5,800,000. The chief industries contributing to these exports are Cocoa, Gold Mining, Kola Nuts, Timber, Palm Kernels, Rubber and Palm Oil, by far the largest, being the Cocoa industry, which, in 1916, accounted for nearly £3,850,000.

For many years the Colony remained very unhealthy for the European and shared with similar colonies the unenviable reputation of being "the white man's grave."

By sanitation, introduced by the British, the conditions have been greatly improved and, by observing the recognised precautions of living, a Britisher can now safely reside in the Colony, provided that the stay is broken at intervals of a year or so. Many improvements have been made by simple surface drainage in the towns and villages and by the clearing of swamps, and the danger of malarial fever has thereby been materially reduced.

The importance of adequate and reliable water supply as a factor in health has long been recognised, and towards the end of last century proposals were made for the water supply of the two most important towns, Accra, the capital of the Colony, and Seccondee.

The former town is situated on practically the same longitude as London, while Seccondee is about 100 miles west of it, and the latitude of both towns is about five degrees north.

In the early years of the present century Mr. C. S. Craven, M.Inst.C.E., was employed by the Colonial Government to make investigations as to flow of streams, rainfalls, etc. Mr. Craven did much useful pioneer work, for the data he collected formed a valuable guide in the selection of water supply schemes for both towns.

In 1907, Messrs. Hunter, Duff & Middleton received instructions, through the Crown Agents for the Colonies, to report upon water supply schemes for the Capital and for Seccondee, and the late Mr. Walter Hunter, Member of Council Inst.C.E., proceeded to the Gold Coast and, in company with Mr. Craven, went over the various sources as to which information had been collected.

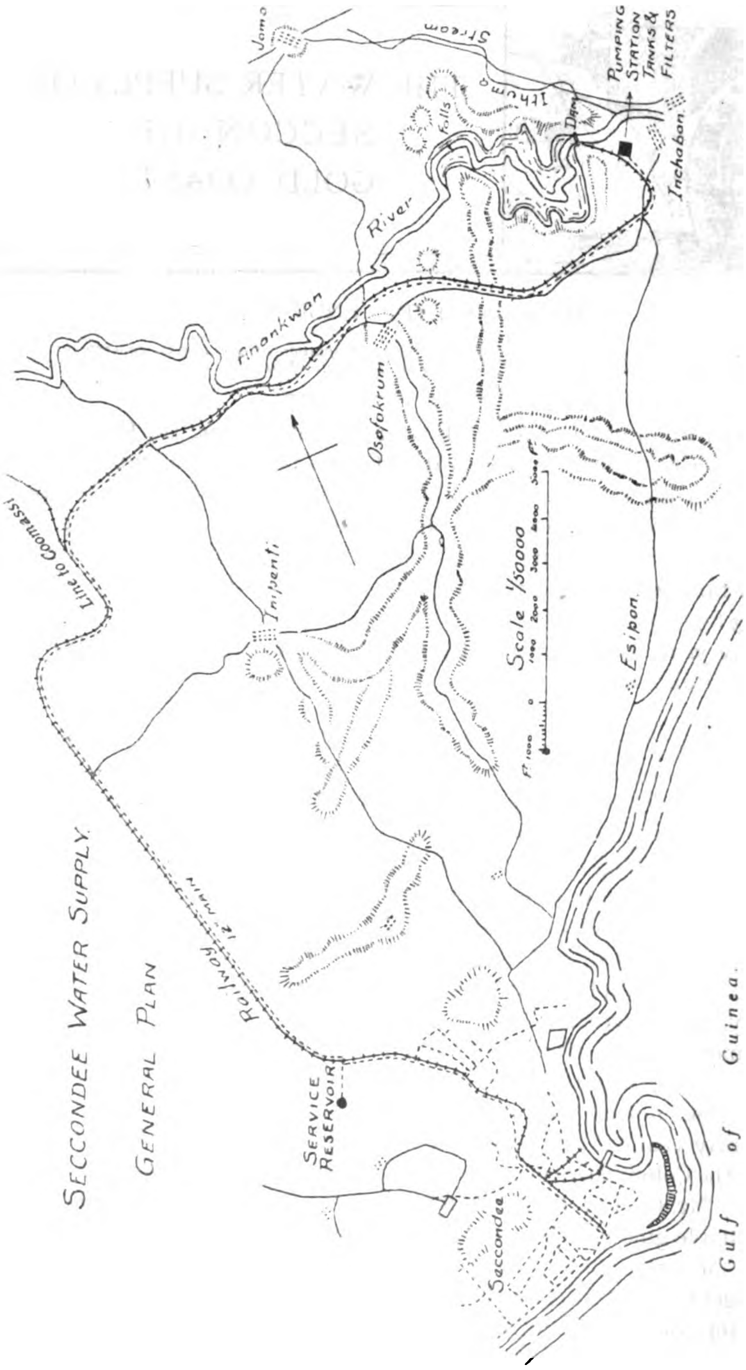


Fig. 1. General Plan.

THE WATER SUPPLY OF SECCONDEE, GOLD COAST.

It was found, on a careful examination of rainfalls and the gaugings of streams, that, in years of low rainfall (such, however, as would be called a large rainfall for the east coast in this country), the run off was so small that a catchment area which at home would afford a large supply with ordinary storage might fail altogether in the Gold Coast, even though storage to meet the demands of several years were provided.

It was therefore necessary, in order to obtain even so small a quantity of water—about half a million gallons per day—as would satisfy each of the towns, to utilise streams which, though in occasional years altogether empty in the dry season, assumed the character of considerable rivers in the wet season.

Such a stream was found in the river Densu for the supply to the town of Accra, and the works were finished in 1914–15.

For the town of Seccondee, with the introduction of a water supply to which this article deals, the Anankwan river was selected, a reservoir being formed in the river bed near the village of Inchaban, at a distance of about 3½ miles, in a straight line from Seccondee.

The needs of the town were considered up to the year 1924, when it was estimated that the quantity of water required would be 658,500 gallons per day, and the works were designed in the first place to afford a supply of 500,000 gallons per day.

From the available data, the estimated average rainfall worked out at about 43 in. per annum, and the available supply from the river was calculated to be 1,040,000 gallons per day, so that the required supply was only 66 per cent. of that available.

The water is of low mineral content, but is highly charged with organic matter, chiefly of vegetable origin ; it was therefore necessary that it should be filtered before being used.

The works consist of a concrete dam with outlet works and sluices for passing floods, filters, clear water tank, pumping station, service reservoir and the necessary mains and contingent works. A glance at the general plan, *Fig.* 1, will show that the site of the reservoir is almost at the sea coast ; unfortunately there was no suitable site farther upstream, consequently the reservoir had to be made at this low elevation, and pumping machinery introduced to lift the water to a service reservoir high enough to supply the town.

The dam (a general plan and an elevation of which are given in *Fig.* 2 and a section in *Fig.* 3) is 360 ft. long, with a maximum height above the original surface of the rock in the river bed of about 40 ft., and two large sluices are provided in the centre for passing flood water. Flood water can also be passed over the top of the dam, but the intention is to use the sluices as much as possible, so that the less pure water which settles to the bottom may be scoured out from time to time.

The dam is faced with concrete blocks in courses 2 ft. deep, the upstream blocks being smooth-faced and the downstream blocks rock-faced. The main body of the dam between the blockwork is of 6 to 1 mass concrete containing displacers, which were specified not to exceed 15 cwt. in weight. As a matter of fact, however, owing to the nature of the schistose rock forming the foundation

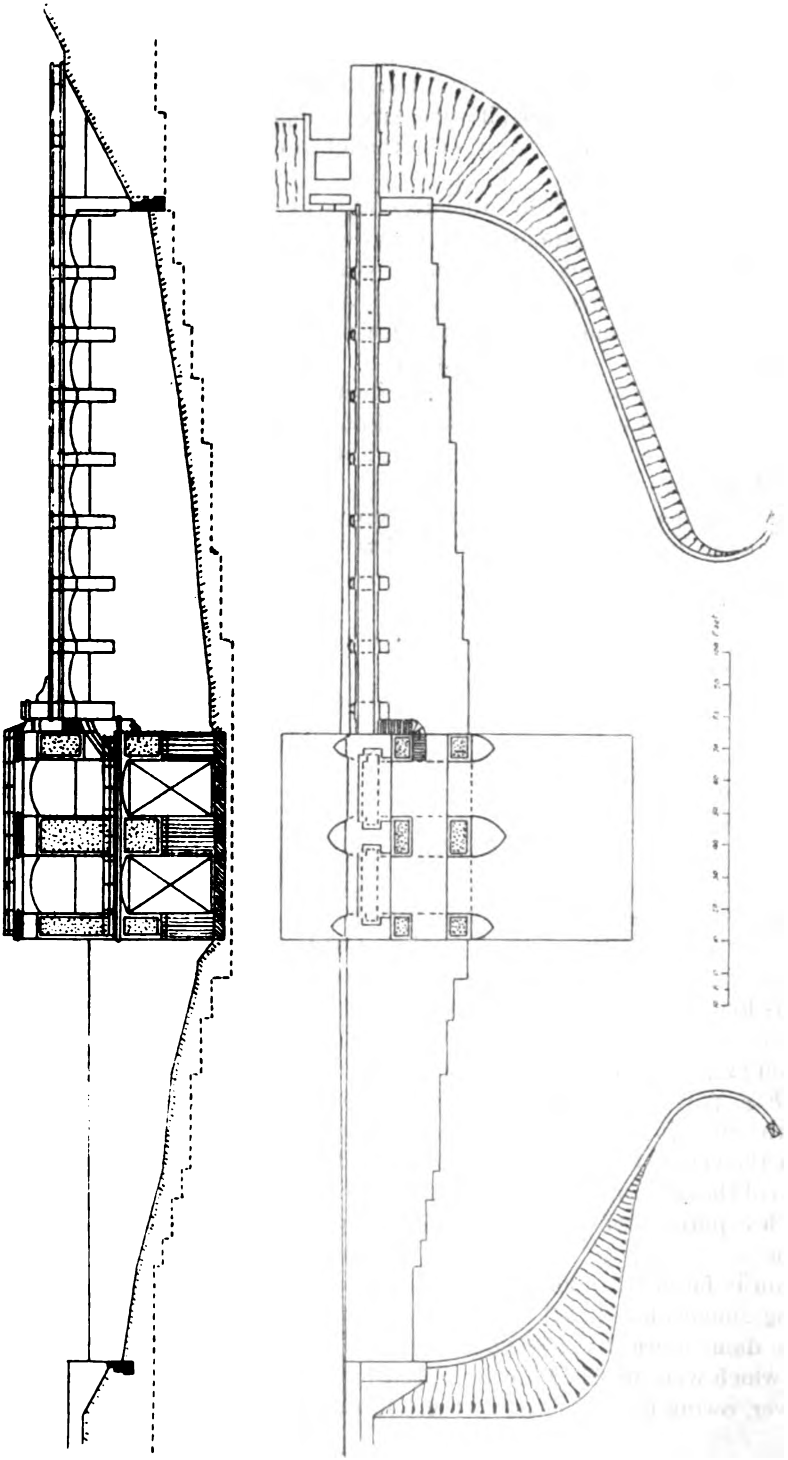


Fig. 2. General Plan and Elevation of Dam.

The Water Supply of Seccondee, Gold Coast.

of the dam from which the stone for the dam was taken, it was not possible to get displacers of material size. The blocks have a face 3 in. thick of 3 to 1 concrete, the remainder of the block being 5 to 1 concrete. The concrete work round the sluices is 6 to 1 faced with 3 to 1 fine concrete. The cement and aggregates were so proportioned that the 3 to 1, 5 to 1, etc., concretes practically mean that in the finished work the bulk of the cement is a third, a fifth, etc., of the whole volume.

The sluices are on the Stoney principle, each having an opening 26 ft. deep by 18 ft. wide; they are built up of wrought steel plates and sections with the necessary roller paths and rollers; an adjustable bar is provided along the top so as to close down on the lintel and make a practically watertight joint; adjustable bars are also fitted to the sides of the sluice so as to reduce the leakage. The sluices are designed to withstand a head of 45 ft. above sill level, and each sluice is counterbalanced and provided with lifting gear so proportioned that two men can raise the sluice with the full head against it.

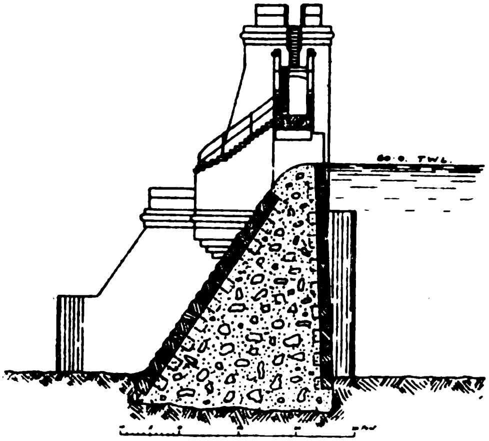


Fig. 3. Section of Dam.
THE WATER SUPPLY OF SECCONDEE, GOLD COAST.

The concrete blocks were made in moulds on the works, and while the blocks were being cast the moulds were placed on a shaking machine, so that they were kept in a constant state of agitation during the process of casting the concrete, thus ensuring a dense and watertight concrete. Recesses were formed in all vertical joint faces of the blocks, these recesses being filled with cement grout after the blocks had been set in the dam, thus dowelling all the blocks together. The blocks were left in the moulds for seven days after casting, and were then taken out and set in the air for a further minimum of 28 days before being used in the work. 3 to 1 Portland cement mortar was used for setting the blocks in the dam.

It was specified that the blockwork should be kept a course in advance of the hearting so as to form the shuttering and render the use of timber shuttering unnecessary in the construction of the dam. The mass concrete was to be worked well up against the back of the blockwork to ensure thorough bonding. In actual construction, however, this method was not adhered to, a novel one, consisting in building a series of longitudinal walls, being adopted upon the advice and responsibility of the engineers in the Colony who were in charge of the work.

Access is given to the sluices by means of a roadway carried on eight arches supported on concrete piers built up from the top of the dam from the north end.

The faces of the sluice piers and of the parapets of the roadway were brushed in panels, leaving the aggregate in relief, to enhance the look of the work.

The ends of the dam are recessed to form keys for puddle walls, which are carried upstream for a considerable distance parallel to the water edge of the reservoir in order to prevent leakage, as the rock does not rise to the full height of the water in the reservoir, and it was found that the ground above the rock was not sufficiently impervious. It was thought possible that a puddle wall would have to be carried round the whole periphery of the reservoir, but a comparatively short length at each end has proved to be sufficient.

The outlet works are situated at the north end of the dam, which is made 14 ft. thicker at this point, and a well 10 ft. by 8 ft. and a screen chamber 12 ft. by 3 ft. are formed in this thickened portion. The banks of the reservoir are cut away to allow easy access of the water, and the slopes so formed are covered with grouted pitching.

The water passes from the reservoir through the screens which are of two kinds, the outer being of iron bars spaced to give 1 in. clear between them, and the inner ones of copper wire gauze having 400 meshes to the square inch.

The passage from the screen chamber to the well is by four 12-in. bell-mouthed pipes each leading through two sluice valves, in series, to a 15-in. upstand pipe. These 12-in. pipes are at different levels to admit of the water always being drawn off near the surface. The supply pipe is taken through the dam from the lower end of the upstand and is 15 in. diameter through the dam, below which it is reduced to 12 in. diameter.

In order to facilitate construction, a timber gantry 30 ft. wide was built on the downstream side of the dam, the rail level on the gantry being 15 ft. below the crest level of the dam. On the side of the gantry nearer the dam a 7 ft. crane road was placed and on the farther side two lines of rails of 2-ft. gauge, one for conveying the concrete from the mixer and the other for returning the empty trucks.

The raw water from the reservoir passes through the draw-off main to a concrete cistern 10 ft. by 9 ft. by 6 ft., the flow into which is regulated by means of a ball valve fitted on the end of the pipe and capable of passing 750,000 gall. in 24 hours when fully open. There are two 6-in. outlets from this cistern, feeding a double row of cascades, 10 in number, introduced for the purpose of aerating the water, which are used to regulate the flow to the filters in accordance with the varying seasonable demands.

A 6-in. overflow pipe is provided in the lowest basin of the cascades and is fitted with a valve, this pipe being used for washing out as requisite.

From this basin the water passes along a channel running across the top of all the filters and supplying them through feeding chambers in the form of cascades.

There are five filters each 80 ft. by 35 ft. by 8 ft. 6 in. deep (see *Fig.* 4), which for the greater part of their area are founded direct on rock, but, where the rock falls away, concrete walls are built up from the rock and the spaces between them filled with rubble stone to form the foundation. These supporting walls are of 7·4 to 1 concrete, while the main body of the filters is of 6 to 1 concrete. The internal surfaces of the filters and filtered water wells are rendered with 2 to 1 cement mortar.

The filtering material is supported on two layers of concrete bars 3 ft. by 4½ in. by 3 in. The bars in the lower of the two layers are laid on the flat, in rows 4½ in. apart. The bars in the upper layer are laid at right angles to those below, but closer together, only a small open joint being left, by which the filtered water drains to the ducts in the lower layer and is led to the outlet wells. In order to keep the bars in place notches are made in the under side of the upper ones into which the lower bars fit. The filtering material consists of 6 in. thickness of broken stone ⅞ in. to 1¼ in., laid on the concrete bars, then 6 in. of stone ⅜ in. to ¾ in., then 2 ft. of sand in two 1-ft. layers of different grades. There is a discharge well 8 ft. square at the bottom end of each filter, the water entering through a 6-in. inlet valve. Each of these wells also contains a Glenfield-Jones regulating valve to ensure uniform delivery within the limits of head allowed in the filter. These valves discharge the water through 6-in. pipes into a 9-in. filtered water main leading to the clear water tank.

The filters are roofed with reinforced concrete 4 in. thick, carried on

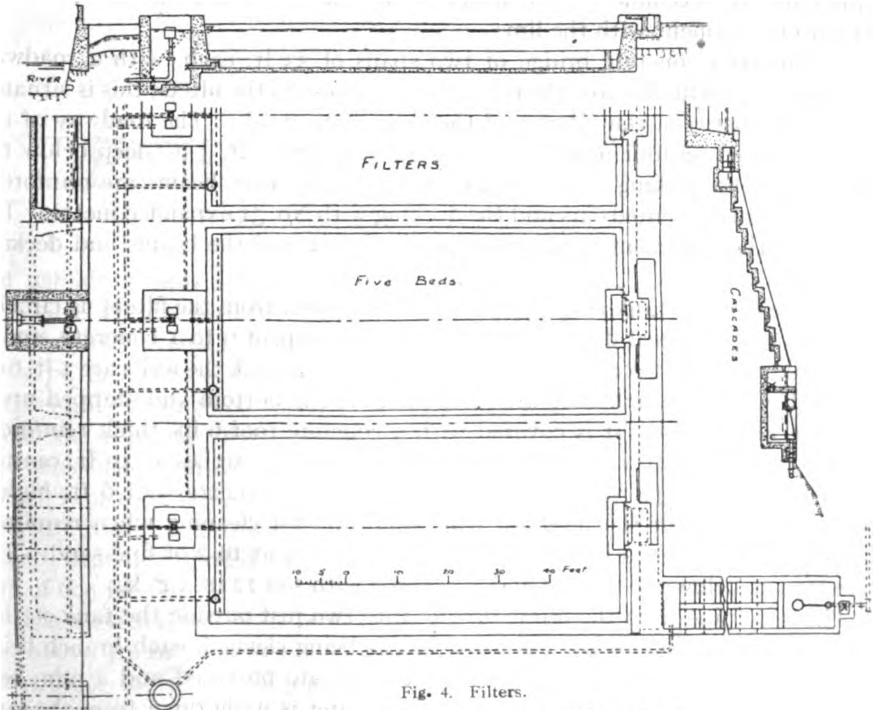


Fig. 4. Filters.

THE WATER SUPPLY OF SECCONDEE, GOLD COAST.

reinforced concrete beams 6 in. wide and projecting 8 in. below the underside of the roof slab, and spaced at 8-ft. centres, the ends of these being supported by beams 12 in. wide and 1 ft. 8 in. deep below underside of roof. These are, in turn, carried on concrete arched walls situated between the filters and by concrete columns 1 ft. 6 in. by 1 ft. situated on the centre lines of the filters. The reinforcement consists of four 1 in. square indented bars in the main beams, three ⅝ in. round bars in the cross beams and No. 8 expanded metal in the roof slab. Each filter is provided with five pairs of doors.

The filters being situated on the river bank are protected on three sides by a training wall of 6 to 1 concrete founded on the rock.

As already indicated the water of these tropical countries is organically highly impure, chiefly through decaying vegetable matter. The problem of filtration was, therefore, a difficult one. At the Accra works it was hoped that by the adoption of multiple filtration a pure filtrate would be obtained without the use of chemicals. While the system succeeded in materially reducing the impurities, it did not afford a water of the standard desired. It was at one time intended to add the iron process, but there were objections to it. Ultimately, on the advice of Sir Alexander Houston, it was decided to adopt the excess lime process, the character of the water being suitable. It was stated by Sir Alexander Houston that the lime would destroy practically all bacteria and also algal growths which were very troublesome in the reservoirs. It has been reported from the Colony that the process has met with complete success, and it has been adopted also at Seccondee. The water is, of course, filtered through the sand filters after treatment with the lime.

A reinforced concrete bridge of two spans of 33 ft. each, with a roadway 12 ft. wide, is provided across the river, to give access to the filters, this is situated so as to lead between the filters and the clear water tank. The roadway of the bridge is carried on four main girders 12 in. wide and 3 ft. 3 in. deep below the underside of the decking, which is 9 in. thick. The main beams are reinforced with 1 in. square indented bars and the decking with No. 31 expanded metal. The concrete of the abutments and centre pier is 6 to 1 and the beams and decking are of 4 to 1 concrete.

The clear water tank (*Fig.* 5), to receive the water from the filters, is circular in form, 100 ft. internal diameter and 11 ft. 6 in. deep, of 6 to 1 concrete, and is excavated partly in rock and partly in earth ; where in rock the walls are 1 ft. 6 in. thick and where in earth they are 3 ft. thick at the bottom and stepped up to 1 ft. 6 in. at the top. It is covered with a concrete roof 6 in. thick reinforced with No. 10 expanded metal and supported by concrete arches at 10 ft. centres, carried on concrete piers 2 ft. 6 in. by 1 ft. 6 in. ; a centre wall 6 ft. high is provided so that half the reservoir can be laid off for cleaning when required ; the inside of the tank is rendered with 1 part of cement to 2 of fine sand. The whole tank is below the ground and is covered with soil 12 in. thick.

The 9-in. pipe from the filters divides into two just outside the tank so that either half can be filled while the other half is being cleaned, each branch being fitted with a 9-in. sluice valve. Two ventilators are provided and a 9-in. bell-mouthed overflow leading to the river. The water is withdrawn from the tank by two 12-in. suction pipes which join just outside the tank and which lead to the pump house which is close to the tank.

The engine and pump house is 54 ft. long by 30 ft. wide internally, and is constructed of concrete blocks 16 in. thick made in a Winget block-making machine; the roof is supported by steel principals. At the back of the engine house is a gas producer house 30 ft. by 30 ft.

The pumping machinery was supplied by Messrs. Tangye, Ltd., and consists of two sets of horizontal treble ram pumps, with rams 13 in. diameter by 15 in. stroke, running at 33½ revs. per min. and driven through gearing by two sets of horizontal suction gas engines of 108 maximum B.H.P. running at 200 revs. per min., these being supplied from two suction gas producers. The pumps draw water from the clear water tank, the level in which varies from 10 ft. to 20 ft. O.D., and deliver it into a stand pipe at the service reservoir about 1 mile from Seccondee, the overflow of which is 225 ft. O.D.

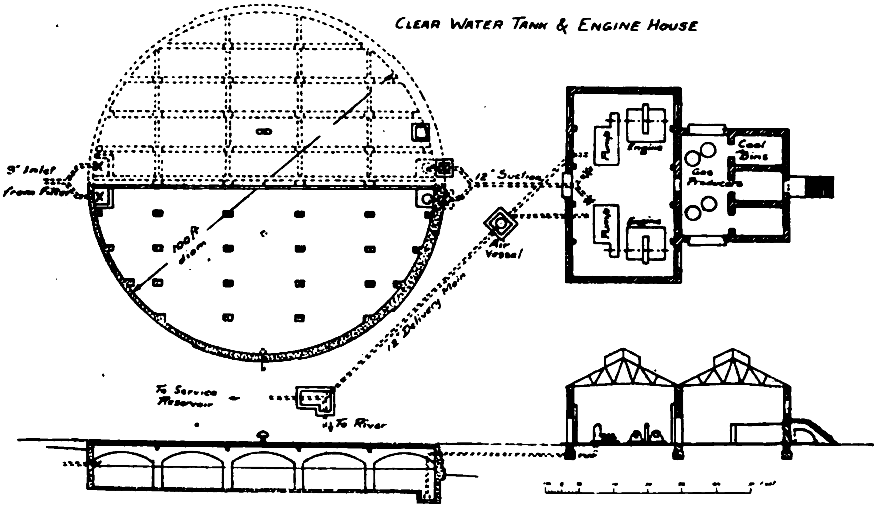


Fig. 5. The Clear Water Tank and Engine House.
THE WATER SUPPLY OF SECCONDEE, GOLD COAST.

The delivery main from the pumps is of 12-in. spigot and socket cast iron pipe and conveys the water to the service reservoir; the main is bifurcated just before entering the service reservoir, the branches delivering one on each side of the reservoir division wall, and each being provided with a sluice valve. Just before the bifurcation a stand pipe 30 ft. high, above the centre of the pipe is fixed, so as to enable a higher head to be put on the main for the supply of villages along the route, it also serves the purpose of a safety device in case the valves on both branches should have been left closed. The pipes were all tested to a head of 600 ft.

The service reservoir (*Fig.* 6) is circular in form, partly excavated and partly built above ground. It is 175 ft. internal diameter and 12 ft. deep from floor to underside of roof, the maximum depth of water to overflow level being 11 ft. It has a centre wall 7 ft. 6 in. high above the floor to enable half the reservoir to be emptied for cleaning. The floor is 12 in. thick and the walls 2 ft. 6 in. at the bottom, stepped off to 1 ft. 6 in. at the top, all of 6 to 1 concrete. The roof is 6 in. thick of concrete reinforced with No. 10 expanded metal and is carried on concrete piers and arches, the arches being 20 ft. span and 10 ft. apart. The roof is covered with soil 12 in. thick sloped off at 3 to 1 all round to meet the original ground. The water leaves the service reservoir by two 12-in pipes, one from either side of the division wall. These join at about 30 ft. from the reservoir, and about 22 ft. beyond this junction a venturi meter is fixed for the purpose of recording the delivery to the town. The venturi meter is situated in a house made of concrete Winget blocks. The 12-in. main is continued to a point in the town where it divides into the general distribution system. Two 9-in. Deacon meters are fitted on the distribution system for detecting waste.

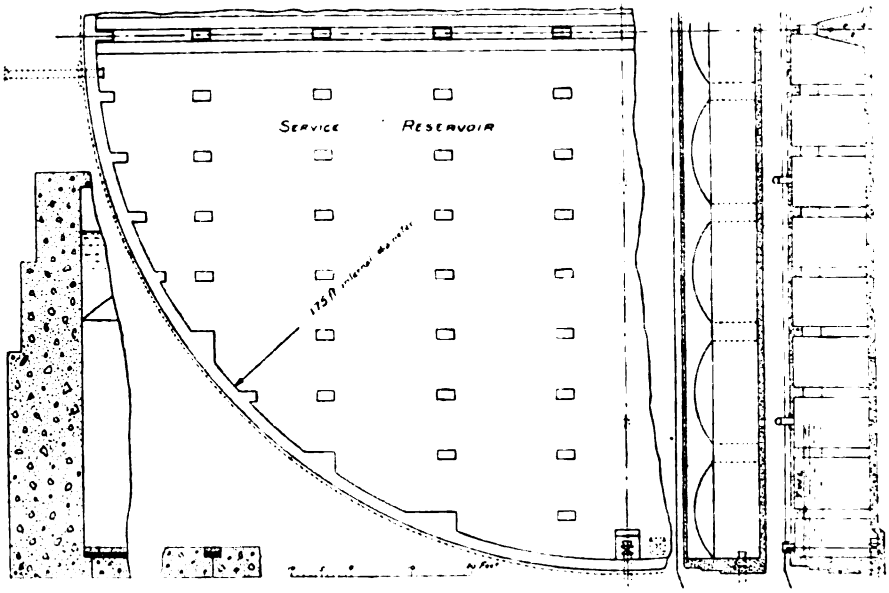


Fig. 6. The Service Reservoir.
The Water Supply of Seccondee, Gold Coast.

The completion of the works was much delayed owing to the war, and the cost, consequently, considerably increased.

In order to facilitate the construction of the work a branch railway, about 3½ miles long, was laid from the Seccondee-Coomassie line to the site of the dam. It was made of the same gauge as the main line and cost about £17,000. The cost was subsequently paid by the Gold Coast Railways department, as it was arranged at the outset to construct the railway so as to carry passengers and serve the town of Chama and other villages in the neighbourhood of the reservoir.

In Seccondee the water is introduced to the bungalows of Europeans, and the natives are supplied by street fountains situated at frequent intervals.

The inception of the works at Accra and Seccondee was made while the late Sir John Rodger was governor, and both the Accra and Seccondee works were completed during the governorship of Sir Hugh Clifford, K.C.M.G.

# CONCRETE COTTAGE CONSTRUCTION.

## HOUSES AT LIVERPOOL AND COVENTRY.

Most systems of concrete construction which build with a block, either pre-cast in a factory or workshop, or site-moulded with local aggregate, make it on the semi-dry principle : that is, they sufficiently compress the mixture in a machine so that it will retain its shape on immediate removal during the process of drying. The alternative and less used method is to make the block in a mould into which the mixture is placed in a thoroughly liquid condition and allowed to dry slowly. The comparative merits of these two systems have been sufficiently argued elsewhere, and the unpopularity of the latter method does not lie in the fact that it is in any way less efficient, but that it is somewhat less rapid and requires a large number of moulds.

Some cottages have been erected in the West Derby district of Liverpool, and another pair are nearing completion at Coventry on a somewhat novel method, one of the features of which is that the blocks which form part of the structure are mixed wet ; they are made in shallow moulds, a detail of which is shown in *Fig.* 1, consisting of a wooden frame and pallet with galvanised iron lining. The mixture is placed wet in the mould, which is then shaken in order to eradicate voids. It is allowed to remain in the mould until setting has commenced, the hinged sides and end of the mould are then lowered, and the panel removed on its pallet and allowed to season. About eight pallets are required with every mould.

The patentees of this system, which is known as Piers and Panels system, are Messrs. Panels, Ltd., and as the system is of unusual interest, it will be described in detail.

Concrete foundations are laid in the usual manner, and on them a solid concrete wall 1 ft. in thickness is built up until the horizontal damp-proof course level is reached, which is about 6 in. above the finished ground level. On this a 12-in. by 6-in. splayed plinth block is placed, the top surface of which is 9 in. wide. These blocks are perforated at intervals, the exact position of these perforations being decided by the position of the panels which form the upper part of the wall. Through these perforations are placed ⅜-in. solid steel rods,

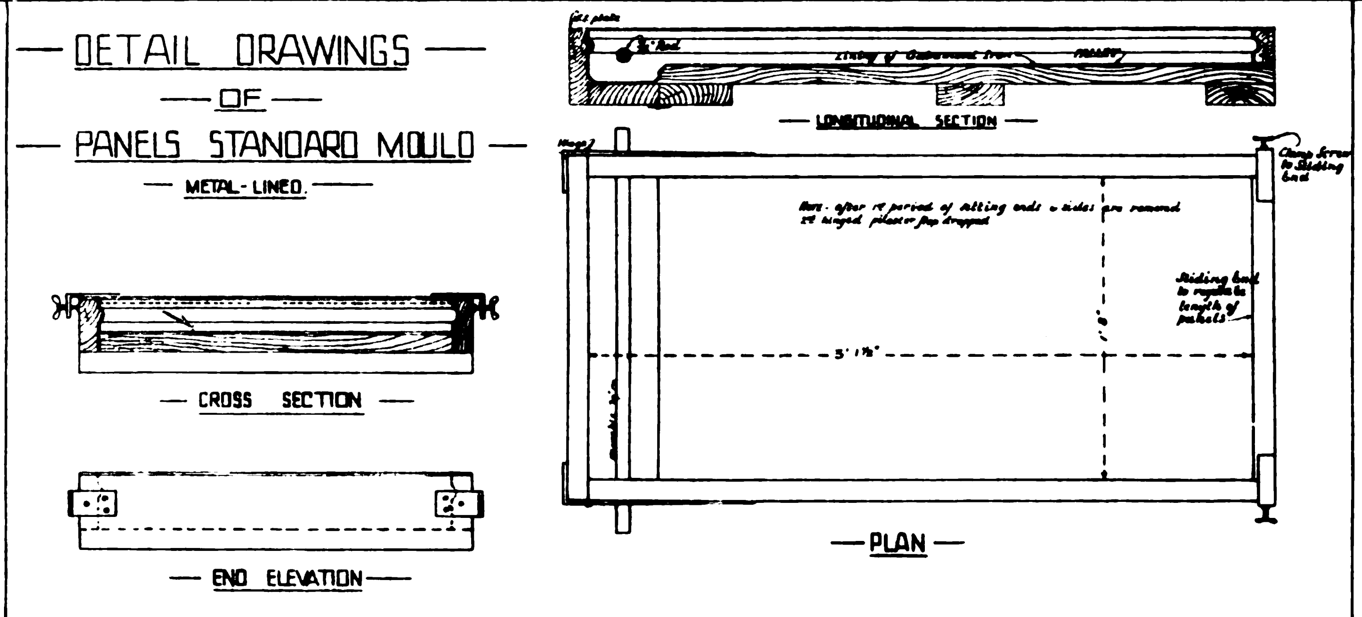


Fig. 1. Details of Moulds for Making Blocks
Houses at Liverpool and Coventry.

secured by nuts, and an 8½-in. by 2½-in. by ⅛-in. W.I plate. These rods are continued in 6-ft. lengths, bolted together, to the eaves. The external walls have at their salient angles and at points not more than 12 ft. apart along the length of the wall hollow piers built of concrete blocks 12 in. by 12 in. They are grooved to take the panels. These blocks are filled with concrete *in situ*, and reinforced with ⅝-in. steel rods. These piers run through the plinth course and are continuous to the eaves.

Above the plinth course, and between the piers, the outer walls are constructed of two thicknesses of panels. These panels, whose method of manufacture has already been described, are made of a four to one mixture, the aggregate being made to pass a ½-in. square mesh. The panels on the inner side of the cavity are made with breeze aggregate in order that they may be more absorbent, and thus mitigate the chances of condensation. The size of the panels is 2 ft. 10 in. by 1 ft. 8 in. by 2 in., with a rib at one end 4 in. by 3 in. This rib is pierced with a hole, and through it the steel rod passes. The panels can be reduced in length where required at window openings, door jambs, and the like by means of the sliding end to the mould. Galvanised iron wall ties are built in at the centre of each panel, and at the end, over the rib, where they are specially pierced to allow the ⅝-in. rods to pass through them. The panels are grooved and tongued. The cavity formed between the two panels is 5 in., making the total thickness of the wall 9 in.

Above the heads of the windows, and immediately below the first-floor joists, is built in a 9-in. by 6-in. concrete stringer; this, it must be admitted, seems a somewhat risky mode of construction, for it forms two complete horizontal joints through the entire thickness of the wall. The floor joists rest on this beam, which thus has the effect of distributing the load. Above the stringer the construction is continued in the same way, except that the lowest inside course of panels is grooved to allow for the joists. Above the first-floor windows is placed another solid 9-in. by 6-in. concrete stringer. Through this the ⅝-in. rods pass, and are made fast by nuts and an 8½-in. by 2½-in. by ⅛-in. W.I plate. On this top beam is placed the 4½-in. by 4-in. wall plate. The outside walls are treated with Dieppe Petrifying Paint, and the interior plastering is carried out throughout in Dieppe plaster 3/16 in. thick. The ceilings are formed with Dieppe plaster slabs nailed to the underside of the joists.

It will be noticed that in the pair of houses in Deysbrook Lane, West Derby, Liverpool, a panelled effect has been obtained. This is done by reversing the panels. It will be seen on the detail drawing shown in *Fig.* 2 that the 4-in. by 3-in. ribs on the panels are turned inwards to the cavity. In the houses at Liverpool this process has been reversed. There is no reason why the lower floor should not have the ribs inside and the upper floor have them outside. Provided that no attempt be made to imitate half-timber work, the result might be quite pleasant, and it allows a certain freedom of treatment which some patent systems of construction are apt to deny. The pair of houses at Liverpool cost £1,300. The houses at Coventry are quite different in design: the walls are not panelled, and the gabled projections break the front wall and tend to make an interesting group, and the open porches at the corners give an air of spaciousness

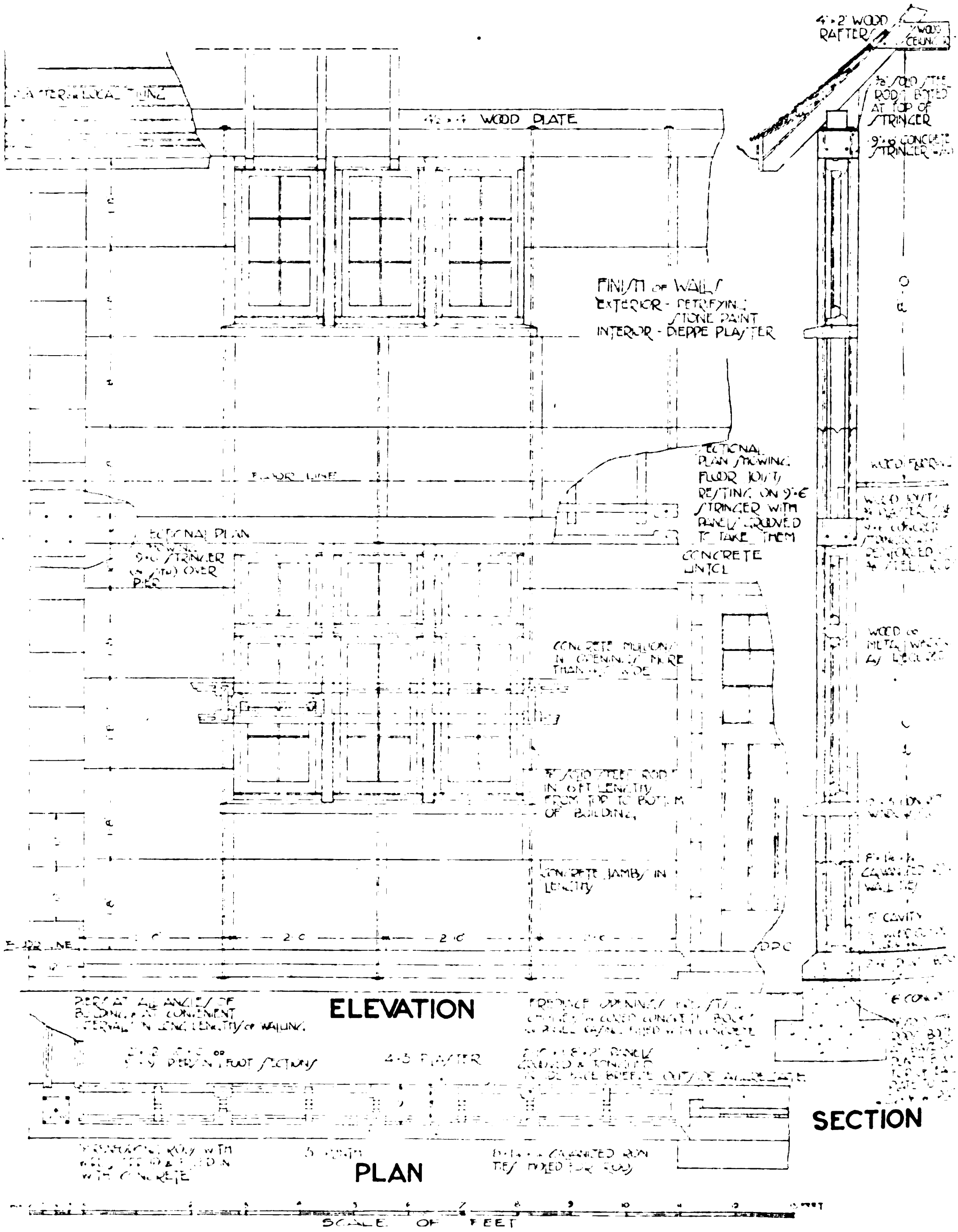

4" × 2" WOOD RAFTERS
WOOD CEILING
3/8" SOLID STEEL ROD BOLTED AT TOP OF STRINGER
9" × 6" CONCRETE STRINGER
WOOD PLATE
FINISH OF WALLS
EXTERIOR - PETRIFYING STONE PAINT
INTERIOR - DIEPPE PLASTER
SECTIONAL PLAN SHOWING FLOOR JOISTS RESTING ON 9" × 6" STRINGER WITH PANELS GROOVED TO TAKE THEM
FLOOR LINE
SECTIONAL PLAN SHOWING 9" × 6" STRINGER (IN SITU) OVER PIER
CONCRETE LINTEL
CONCRETE MULLIONS IN OPENINGS MORE THAN WIDE
3/8" SOLID STEEL ROD IN 6FT LENGTHS FROM TOP TO BOTTOM OF BUILDING
CONCRETE JAMBS IN LENGTHS
2'-0"
2'-0"
DPC
PIERS AT ALL ANGLES OF BUILDING & AT CONVENIENT INTERVALS IN LONG LENGTHS OF WALLING
ELEVATION
4.3 PLASTER
SECTION
PLAN
SCALE OF FEET

Fig. 2. Details of Construction

Houses at Liverpool and Coventry.

which is particularly welcome just now when it has become so necessary to exclude all but the most essential features on account of expense.

These houses do not form part of a housing scheme, although the houses at Liverpool almost conform to the Ministry of Health's type " B," the exception being that the living-room and parlour are too large, whereas the third bedroom is too small. The houses at Coventry with this large living-room and drawing-room, the latter with a superficial area of 175 ft. super, exclusive of the ample bay-window, could hardly be designated " working-class " houses.

With regard to cost and speed of erection, the patentees claim a saving of from 20 per cent. to 25 per cent. over a similar structure all in brickwork ; they furthermore state that the walling for a six- or seven-roomed house can be put up in from ten to fourteen days. This does not include the manufacture of the panels, although some of this work can proceed simultaneously with the erection. And this opens up the question as to whether, in reckoning the time taken to erect a house, the time spent in making the blocks should be included. The time taken in making the bricks is not considered with each individual house ; but there is this difference : bricks do not have to be specially made for a particular house, whereas in each house there are a certain number—the exact figure varying with each plan and with each type of construction—of blocks which must be specially made, and in estimating the time of erection this item must be included. The man who is about to build a house is concerned with the moment when it will be ready for occupation, and if he contemplates adopting concrete, he wants the advent of this moment to compare favourably with brickwork. It is nothing to him that

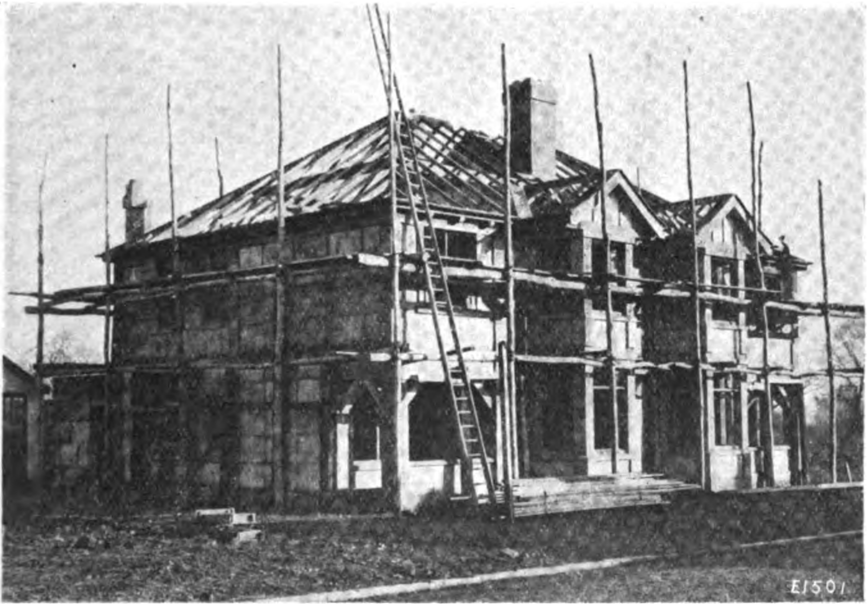


FIG. 3. HOUSES IN COURSE OF CONSTRUCTION AT COVENTRY.

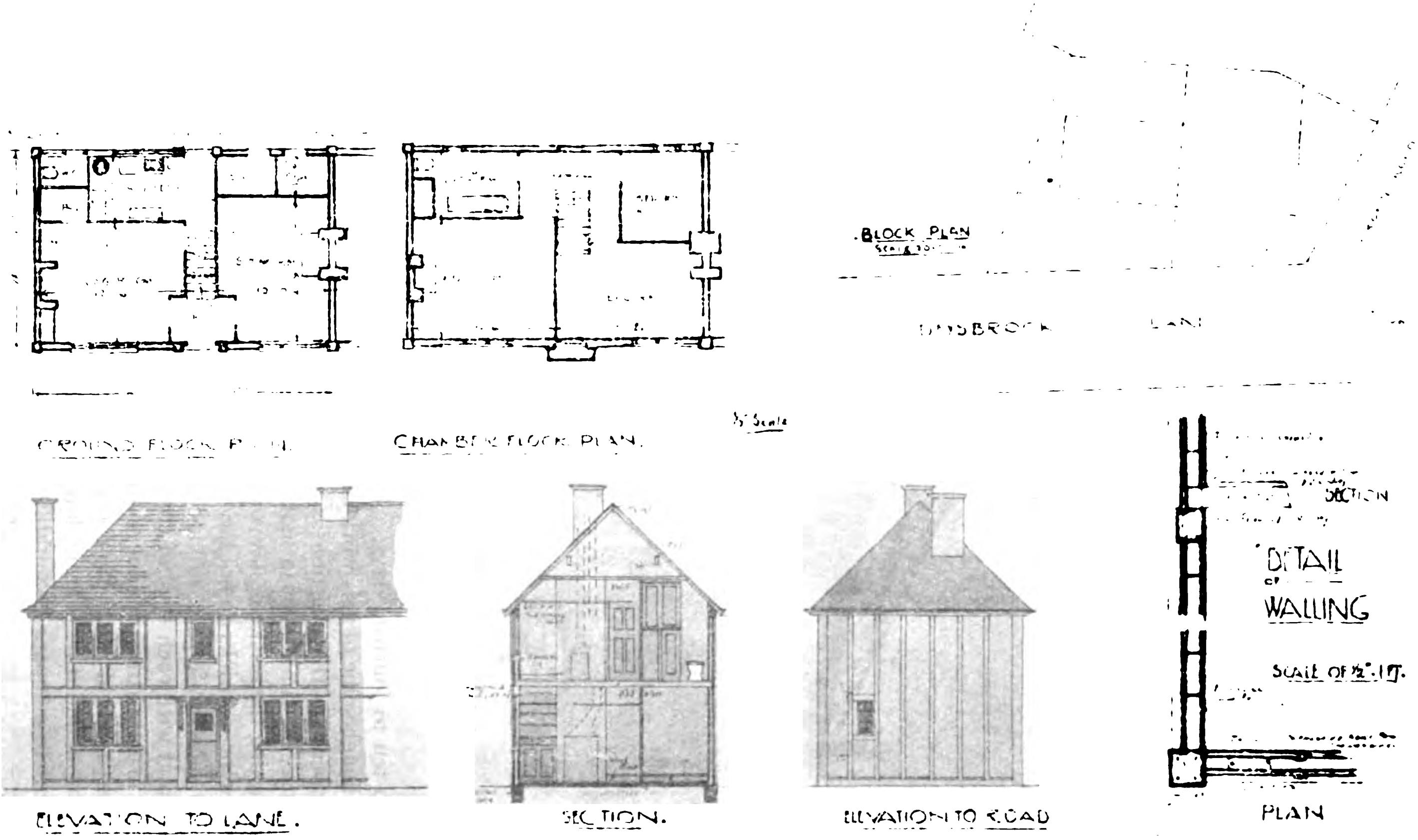


Fig. 4. Plans and Elevations of Houses at Liverpool.

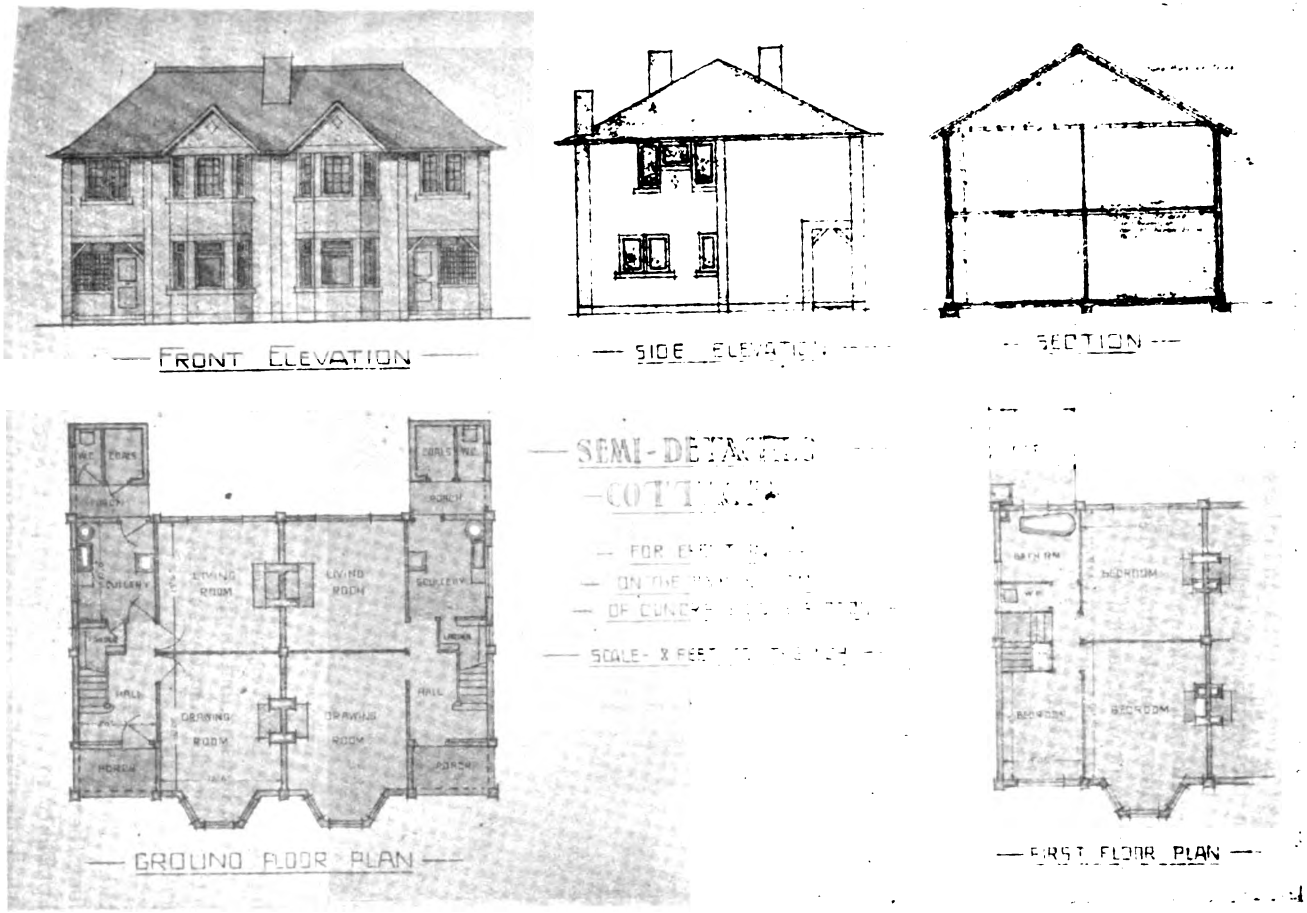


Fig. 5. Plans and Elevations of Houses at Coventry,

the actual erection may only take three weeks if the preparation of special drawings and the manufacture of special blocks is to take two months. Contractors, inventors of patent systems, and others directly concerned should be particularly careful in the statements that they make in regard to the time required for erection. There are many persons who will seize on any opportunity that may bring discredit upon concrete as a building material for cottages and small houses, and ambiguous or misleading statements afford them just what they require.

Most of the work carried out by this system has been undertaken by licensees, reputable builders being appointed by the company for this purpose. The company hope, however, very soon, owing to the large amount of work in prospect, not only in housing, but in the erection of factories and the like, to undertake the erection of work themselves; this, of course, will have the effect of still further reducing the price.

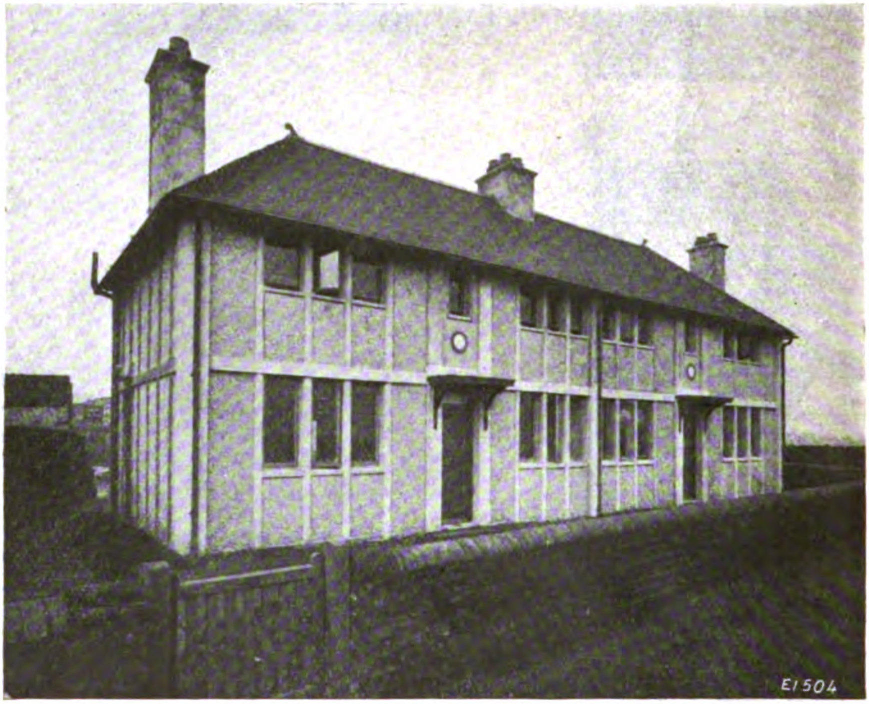


Fig. 6. View of Finished Houses at Deysbrook Lane, West Derby, Liverpool.

The system is an interesting one, although it would seem somewhat complicated. The perfect concrete house is yet to be achieved, but without a doubt among the qualities that will be sought for are simplicity in construction and adaptability to any design without a disconcerting amount of special work, either in the preparation of drawings or of parts.

# CONCRETE ROADS.

By EDWIN TOMLIN.

PERHAPS there is no phase of American and Canadian national life more remarkable since the close of the Great War in Europe than the demand for permanent highways, from the Atlantic to the Pacific. This demand is rapidly growing in strength as the expression of the will of two free peoples, until it has reached a stage where the civic, state, provincial and national governments of the day can no longer ignore the popular voice. All over the United States and Canada, people will no longer tolerate a dirt or macadam highway, and both are doomed.

One might give a variety of reasons for this widespread demand for permanent highways. Some writers urge that the experience of the battle front showed conclusively that only roads of a permanent nature could withstand the terrific traffic inseparable from modern warfare. That the French macadam roads stood up at all is somewhat of a marvel, and was only possible through the small armies of men who were kept constantly at work, renewing the surface.

Other writers urge that the breakdown through congestion of the railroad system in the United States during 1916 and 1917 was primarily due to the load thrown on the trunk roads which they were unable to withstand. Other writers yet, again, attribute the present demand for permanent roads to the high cost of the necessaries of life, claiming that the truck gardener, the dairyman, the fruit grower, the stock breeder, the farmer and other land workers cannot be expected to deliver their wares economically to market if they have to travel over roads which are rutty and rough at the best of times, and like a ploughed field during the winter months. The value of time and effort as national assets of importance is realised more to-day than ever it was in the past, and the state has no right or mandate to compel its citizens to waste either by travelling over poor roads when they might easily be conserved for use in other ways.

We have not yet exhausted the reasons which are given for the good roads propaganda which is with us to-day. The motor-car enthusiasts are boldly and loudly proclaiming that the automobile has torn the heart out of the macadam and dirt roads, and that, seeing this form of locomotion promises to be all-predominant in future, the roads must be made of a permanent nature.

Education has undoubtedly done a great deal towards fostering the present widespread demand for a national policy in regard to road building. The unfolding of ideas in this regard has been very slow, and to-day we simply marvel why our fathers and our grandfathers patiently contented themselves with the old-fashioned country highway. It may be argued that the traffic in those days did not tear up the roads so much as modern automobiles, but even so, some of us remember quite well how, in our childhood days, we looked upon mud on our roads as the natural consequence of the winter season of the year.

### A GOOD ROAD SAVES TIME.

Years ago we did not seem to have been so impressed with the idea as we are at the present, that it pays to keep out of the mud. Bad roads are the cause of a frightful waste of physical and nervous energy. A cry which is heard all over the world to-day is the necessity for greater production. Is it not rational to ask that the state, when making this demand upon the people, should itself take all reasonable measures to avoid waste of time and energy to useless ends ? The artisan on his bicycle or on foot who has to travel a mile or two miles over bad roads in winter-time to the factory or workshop can justly claim unnecessary waste of energy in arriving at his place of employment. Bad roads and good roads are both matters of public interest and concern, a fact which is gathering strength year by year. If one could sum up the man-power and horse-power hours which are wasted annually all over the world through bad roads, we should be astounded at the loss of time and energy. Applied nationally, one cannot help being reminded of the words of the late Mr. W. E. Gladstone, when he wrote, " Believe me when I tell you that thrift of time will repay you in after life with a usury of profit going beyond your most sanguine dreams, and waste of time will make you dwindle alike in intellectual and in moral stature beneath your darkest reckoning and calculation."

### THE FINANCIAL ASPECT.

In meeting the popular voice and seeking to grapple with this widespread demand for permanent roads, the authorities are confronted with the all-important question of finance. The maintenance of the old macadam, gravel and dirt roads has been more or less generally arranged by yearly appropriation from public revenues. The building of permanent roads in substitution for macadam, gravel and dirt roads cannot be financed in that way. As a result we see a great variety of proposals being placed before the public and governing bodies to meet the situation. The Automobile Associations suggest that automobile licences should be earmarked for permanent road construction purposes, but this proposal is not sound, as it impairs the credit borrowing powers of a public body. If the principle were carried to excess, bonding houses would be very sceptical about raising money for Governments whose general revenues were earmarked for special purposes.

Other suggestions for financing permanent roads have been along the lines of Government aid to municipalities, according as the road to be paved is of the main highway class, semi-highway or ordinary country road. In countries like Canada and the United States it looks as though the final method of financing will be along the lines of Federal aid to the various states or provinces, and a comprehensive system on the part of the latter to the cities and municipalities.

### WHAT IS THE BEST TYPE OF PERMANENT ROAD ?

We now come to the general broad question of the best type of permanent road for present and future traffic. There are several roads of asphaltic composition, brick roads, granite sets, wood blocks and concrete. One may read reams of discussion by interested parties advocating their own particular class of road, and to attempt to be a judge in this matter is tantamount to inviting trouble from those who have axes to grind. It is possible, however, to state one or two essential features in a permanent road which form, as it were, a sort of standard specification.

Any so-called permanent road which, while not itself rigid, requires a rigid base to ensure success cannot be classed as a road at all, but only as a top dressing. The asphaltic and bitulithic roads all fall within this category. Without a concrete or heavy rock or stone base they are only temporary expedients. Under the pressure of heavy traffic they become rutty, lose their crown, and in hot weather curl up in ridges where the subgrade has failed to withstand the weight of the traffic.

Roads composed of vitrified brick, wood blocks or granite sets, while possessing much greater wearing properties than asphaltic or bitulithic roads, at the same time are dependent again on a rigid base of concrete, rock or stone, as well as a sand cushion, to ensure a perfect crown. It will be quite obvious that these last three types of permanent pavement are very expensive if the base is properly prepared, as, of course, the latter is an expensive item in itself. Skimping the work on the base, however, would be fatal to the success of either vitrified bricks, wood blocks or granite sets, as the weight of heavy traffic would rapidly destroy the crown of the road, quickly dispelling any idea of the permanency of such a pavement.

There is only one road which can be truly said to be sufficient in itself, a road that is without a peer in strength and endurance. We refer to the concrete type. It needs no special hard base to rest upon, as is the case with asphaltic, bitulithic, brick, wood blocks and granite sets types. Given a subgrade which has been properly rolled and graded, the concrete pavement on top will provide the rest. In all other cases a properly rolled and graded subgrade is necessary, then a rigid base, and on top the asphaltic, bitulithic, brick, wood blocks or granite sets in order to ensure success. In other words, concrete pavements only require two operations, while all other so-called permanent roads require three. From the standpoint of endurance and strength, concrete is superior to all of them, excepting perhaps granite sets if placed on a concrete base, but, as is well known, this latter type of pavement is extremely expensive, and can, therefore, be ruled out of court as a factor for consideration in the broad permanent highways of the future.

### THE DEVELOPMENT OF THE CONCRETE ROAD IN THE UNITED STATES AND CANADA.

Concrete roads made a modest beginning in Wayne County, Michigan, fourteen years ago, and in Canada over twenty years ago. Wayne County, Michigan, is justly entitled to pioneer honours as a public body which for fourteen years without a break has steadily and persistently paved its roads with concrete, improving on the standard year by year until at the present time their roads are a model for the entire continent of America. It is anticipated that in a few years there will be no less than 350 miles of concrete roads in this one small county out of the many thousands in the United States of America.

Concrete roads have not reached their present pre-eminent position without receiving a severe gruelling at the hands of every shade of engineering, road building, municipal, state and federal opinion. The technical professors of universities, the skilled scientists of the Bureau of Standards, the State Highway Commissions of America, and many other private and public bodies have all in turn demanded that concrete roads shall show just cause for their widespread use as a permanent pavement. It would require a very long article by itself, in fact a book, to describe the changes of method and the revolution in the building specifications which have taken place during the last fifteen years. Suffice it to say that concrete roads have come through the ordeal absolutely triumphant; and, from the indications which are now patent to the public everywhere, the concrete road bids fair to outstrip all others in general acceptance for future programmes. During the ten years ended December 31st, 1919, there were laid in the United States and Canada 15,851 miles of concrete roads, streets and alleys. The year 1919 alone shows the peak record to date when 53,000,000 sq. yd. of concrete road were placed under contract. This yardage is equivalent to over 5,000 miles of concrete pavement 18 ft. wide. During the present year, 1920, it is anticipated that there will be over 75,000,000 sq. yd. of concrete roads constructed in Canada and the United States.

Like a tide in flood the concrete type of permanent road is moving forward irresistibly, and carrying before it all opposition. Of all the permanent roads offered for public acceptance to-day, concrete alone offers at the lowest first capital cost, and at the lowest maintenance, the road that can successfully withstand the heavy traffic of to-day, to-morrow and the years to come.

### CONCLUSION.

Even in Great Britain, where the staid conservatism of centuries more or less effectually prevents any rapid innovations in road construction, we find the concrete road is making a general appearance. Several of the most eminent road authorities in Great Britain are now paying serious attention to the accumulated evidence of the excellence of concrete roads in Canada and America, and we may expect to see before long a general programme of concrete road building in the British Isles.

As a concluding word on this subject, and as a tribute to the pioneers in Wayne County, Michigan, the writer does not think he can do better than quote the now famous statement made by Mr. Edward N. Hines, chairman of the Board of County Road Commissioners of Wayne County, Michigan, when he said, " Any community that wants a good road, a road that is cheaper for even a short time than any other good road, a road that is inexpensively maintained, a road that is sanitary and dustless, a road that is not slippery, a road that affords good traction for any type of vehicle for three hundred and sixty-five days of the year, a road that in the long run, say ten, fifteen, twenty years or longer, is the cheapest of all good roads, should investigate the merits of concrete."

## MEMORANDA.

**Penybont.**—The Penybont Council have decided to erect 400 houses in concrete construction at a price between £800 and £900 per house.

**Llanelly.**—150 reinforced concrete houses are to be erected at Llanelly.

**Liverpool.**—Tenders for the erection of 2,000 concrete houses with standard joinery fittings and for the conversion of 136 Army huts into dwellings at Knotty Ash have been accepted by the Liverpool Housing Committee.

**An Ideal Village.**—We understand that *The Daily Mail* has decided to organise a permanent exhibition to demonstrate new methods of house construction. Subject to a suitable site being found in the immediate neighbourhood of London, firms who are devising and promoting new methods of construction will be invited to erect specimen cottages in *The Daily Mail* Ideal Village. The exhibition will probably be open for three months. Each house will be built of a different material or by a different method. There will be concrete houses, asbestos houses, sand and cement houses, wooden houses; in fact, every kind of house which English manufacturers are in a position to provide. The Ministry of Agriculture is to be invited to show an Ideal Allotment as a permanent exhibition in the village, and also an ideal plantation of fruit trees. Spaces will be placed at the disposal of the Ministry to demonstrate bee, poultry, and other small livestock rearing.

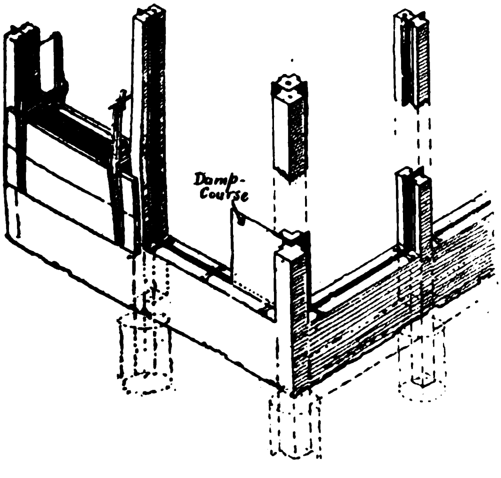
# THE BUILDING TRADES' EXHIBITION.

*The above illustration is reproduced from the Catalogue of the Exhibition.—ED.*

THE first Building Trades' Exhibition since 1914, held at Olympia from the 10th to the 24th of last month, was a great success, especially as illustrating the remarkable progress being made by concrete in the construction of small houses, and its adaptability to many other purposes for which other materials were alone thought to be suitable. The Concrete Utilities Bureau performed a very useful service at its artistically-designed stand, constructed of rough-casted asbestos cement sheeting and timber, in distributing free literature and giving advice to those interested in concrete and cement and its manifold applications. A large number of visitors called at this stand. The Exhibition is referred to in our Editorial pages, and we give here a review of the stands of more particular interest from the concrete engineer's point of view.

## BUILDING CONSTRUCTION.

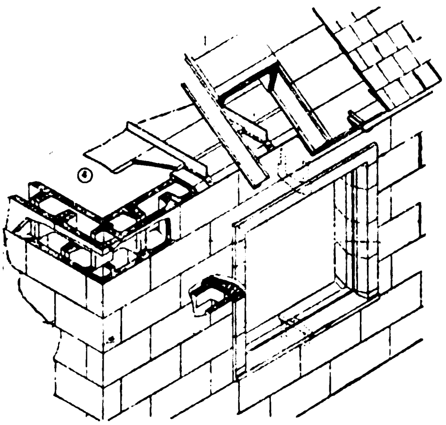
The "Dry-Walls" system, shown by DRY-WALLS, LTD. (168, Regent Street, London, W.1), consists of a monolithic concrete wall, erected by sections, with a bituminous damp-course inserted in the centre. This method is the invention of Mr. Maberly Smith. Piers, either of brick or pre-cast concrete, are formed at the angles of the building and also to divide the length of the wall into convenient bays. The shuttering, which is the same length as the distance between the piers and 18 in. deep, is of wood, and is attached to the piers by clamps. Across the exterior and interior forms are other metal clamps, from the centre of which the vertical damp-course is suspended by clips; the damp-course projects an inch or so above the shuttering, so that when the next course above is poured the sheeting will overlap. The concrete is poured on either side of the damp-course and tamped; if desirable, a porous aggregate can be used for the interior. A metal wall tie is used at each course.



"DRY WALLS" SYSTEM OF WALLING.

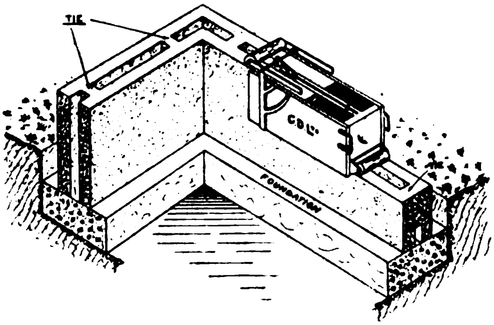
The **Self-Sentering Expanded Metal Works, Ltd.** (2/3, West Street, E.C.2), exhibited a structure in various stages of construction on their well-known method. For walling, a skeleton frame of timber or steel, the vertical members being at about 4 ft. centres, is erected, to which sheets of expanded metal are stapled. The exterior is plastered with 1½ in. of cement, the meshes of the expanded metal being filled with the cement, of which it becomes an integral part. The interior wall, of plaster, asbestos sheeting, or wall-boarding, is then fixed to the inner side of the framing, forming a weather-proof hollow wall. For flooring, "Self-Sentering" expanded metal reinforcement is used. The meshes of this material are small enough to retain wet concrete and, therefore, the necessity for using wooden forms is dispensed with. For partition walls and ceilings, "Herringbone" metal lathing is used and coated with plaster.

The **Channello Construction Co.** (8, Warwick Court, W.C.1.) use a new form of block in their walling. This block, as shown in the accompanying illustration, has deep flanges at each end which ensure a very good joint. The blocks are laid so that the joints on the internal and external walls alternate, thus forming a fairly solid pier every 12 or 9 in., according to the length of the block. The blocks are made on edge on a new type of machine, operated by either power or hand, and are 2 in. in thickness. After the block is tamped the mould is hinged over and the block removed face downwards, and therefore, unlike blocks made on edge without machines, the face may be moulded to represent any design. As the flanges of the blocks of the exterior wall do not quite touch the interior wall, and *vice versa*, a continuous cavity is secured: this type of block is also very adaptable for forming corners. The ground floor is of blocks laid on slabs, and the upper floors are of slabs laid on steel joists.



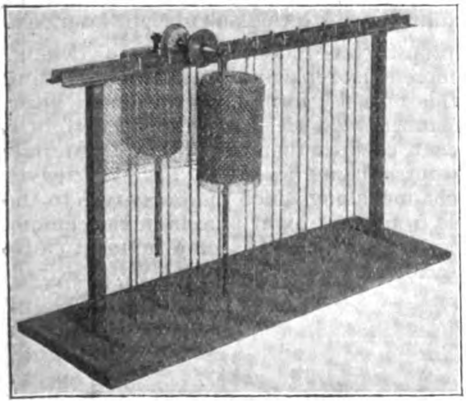
"Channello" System of Construction.

**Messrs. Concrete Dwellings, Ltd.** (5 and 6, Great Winchester Street, E.C.2), showed a new method of building monolithic walls in small sections. The apparatus consists of a movable mould, which is first placed on the foundation and rammed with concrete. After the first section is rammed, the sides are released by an automatic device and the mould is moved along to the extent of its length in readiness for the next section. This operation is repeated until the first course is completed to the height of the mould (12 in., 15 in., or 18 in.), and after an interval of 24 hours from the time of commencement the second course is started, and so on until the required height is attained. For forming cavity walls the mould is made with a wooden partition throughout the greater part of its length, leaving a portion at one end where the wall is built solid, forming a tie between the inner and outer walls. According to the position of this partition the walls may be of unequal thickness.



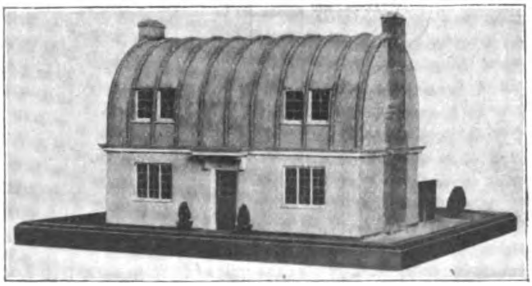
Concrete Dwellings, Ltd., Cavity Wall Construction.

MESSRS. EDWARDS CONSTRUCTION CO., LTD., of Siebert Works, Westcombe Hill, London, S.E.3, demonstrated the Forrester-Marsh system of shuttering for constructing hollow or solid walls. The shuttering consists of two sections of metal sheeting, one flat and one corrugated, secured together to form a rigid sheet, which is placed in conjunction with similar double sheets at the distance required to form a wall of any desired thickness. The sheets are held apart by means of cement or concrete spacing blocks at intervals. Temporary wooden battens are fixed to the outside of the sheeting as strengtheners, and the whole held rigidly together by iron bolts passing through the spacers, the joints of the sheeting and the temporary battens. The spacers are connected longitudinally by metal rods, which also act as reinforcement. After the concrete has been poured and tamped, the sheeting is removed and the hollow cores of the spacers (from whence the iron bolts are withdrawn) are then filled in. Hollow walls are constructed in the same manner, but with double the number of sheets and spacers, and with tie-bolts to hold the leaves apart. The sheets are very rigid, and at the same time light and easily handled; the operations of erection and removal are comparatively simple, and walls may be rapidly and economically erected with their use.



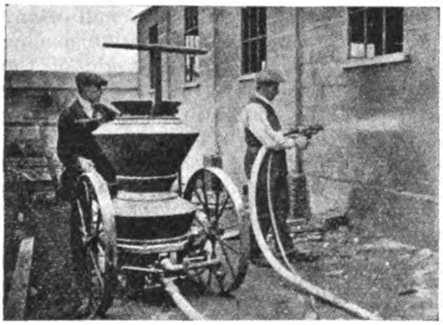
"DUPLEX-SHEATH" CONSTRUCTION.

The DUPLEX-SHEATH CONSTRUCTION Co. (6, Moorgate Street, E.C.2) showed a new method of building. This system consists of a steel structure covered with two sheaths of metal lathing, so placed that each can be coated independently with cement concrete applied by a cement gun, leaving a continuous cavity between the walls. The whole of the weight of the building is carried on steel stanchions, and foundations are only necessary under these supports. At first-floor level a channel iron is fixed to the stanchions, and this runs horizontally around the building, the inner channel taking the concrete floor and the outer channel taking the roof members. These channels also act as runners for a small wheeled carrier from the projecting axles of which are suspended two rolls of metal lathing which unwind themselves as the carrier is moved around the building, thus allowing the lathing to be fixed with a minimum amount of labour. The lathing is fixed to light iron vertical rods, about 14 in. apart, fixed to the channel irons at the top and to the concrete floor at the bottom. The lathing is about 1¼ in. mesh. After the necessary door openings, etc., have been cut out of the lathing, a temporary wooden shuttering is inserted between the inner and outer sheaths and fine concrete discharged against it by a cement gun to a depth of 2 in. on the outside. The inner sheath is coated with cement and finished with plaster. After the exterior and interior walls have been finished, the shuttering is drawn upwards from the first-floor level. The roof is formed of curved panels composed of angle irons set 3 ft. apart and braced with small rods to which the metal lathing is attached. Asbestos sheeting



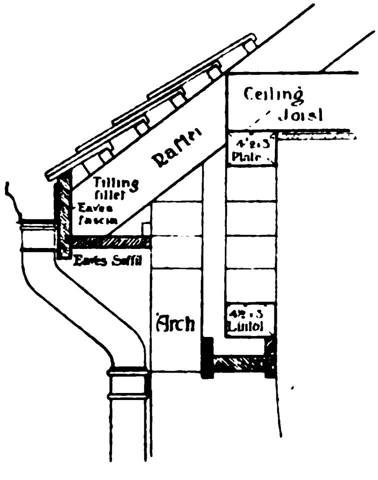
"DUPLEX-SHEATH" CONSTRUCTION.

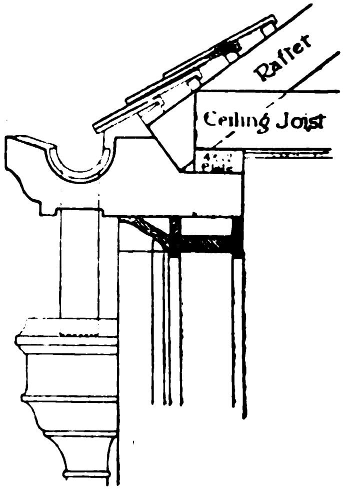
or felt is attached to wooden battens three-quarters of an inch behind the lathing and the outside is then coated with cement by a cement gun. Plaster slabs or boards are fixed to the inside of the battens, leaving a space of 1½ in. between the inner and outer sheaths. The outside of the structure is coated with a damp-resisting material.


"Ingersoll-Rand" Cement Gun.

A novelty in this country, although it is extensively used in America, is the cement gun, and one of these was shown in actual work by the Ingersoll-Rand Co. (165, Queen Victoria Street, E.C.). The cement gun, by applying cement and sand, hydrated at the point of application, to a wire mesh extended between piers or on a timber-frame building, enables a wall to be built with a minimum of labour in a very short time. It is stated that one gun is capable of covering from 1,500 to 2,000 superficial feet of walling one inch thick in an eight-hour day.

The Economic Eaves Co. (9, Southampton Street, Bloomsbury, W.C. 1) demonstrated yet another purpose for which concrete is replacing traditional building materials. The concrete eaves shown by this firm, by forming a continuous beam between the top of the walls and the roof members, add greatly to the strength of a building, and are also claimed to be 20 per cent. cheaper than the ordinary materials used for eaves, the cost of maintenance, of course, being practically nil. The eaves project over the wall face, but as the glazed channel along which the water runs to the rain-pipe is also close to the face it is possible to use a straight pipe from the channel to the ground level, thus dispensing with the bends which are such a frequent cause of stoppages. In the case of hollow walls, they form a very effective wall tie.





Ordinary Eaves. Economic Eaves. Concrete Eaves.

Several systems of concrete house-building which were exhibited have already been described in our pages, including the "Waller" system (January, 1920); the "Doric" system (March, 1920); the "Unit" system (November, 1919); the "Cat-Ar" system (described October, 1919, illustrated February, 1920); and the "Lean" system (October, 1919).

The Climbing Steel Shuttering Co. (515, Queen's Road, Sheffield) exhibited their patent shuttering of galvanised-steel plates. The inner and outer shutters are held apart by wires which pass through holes in the upper and lower edges of the shutters. After the concrete has set the lower wires are cut and the plates turned upwards and again wired, in readiness for the next course, the top wires acting as hinges. This system has the merit of extreme simplicity, but as they swing upwards the shuttering can, of course, only be used for building solid walls.

## ASBESTOS CEMENT.

Some extremely well-designed structures of asbestos-cement sheeting on timber and steel frameworks were shown. This material, owing to its lightness, ease of handling and the rapidity with which it can be erected, has a great future before it, especially for such purposes as bungalows, summer houses, garages and such-like buildings. When lined inside with wall-boarding or similar material, these buildings are perfectly dry and the air-space between the inner and outer walls ensures a fairly equable temperature.

*Asbestos Cement Gutters.*—An entirely new application of asbestos cement was shown by the British Everite & Asbestilite Works, Ltd., who exhibited samples of gutters and rain-water goods in thin asbestos cement. Those on view were coloured grey, and, of course, can be made in any desired colour. Besides being cheaper in first cost than the ordinary cast-iron gutters and accessories, the economy in up-keep is obvious as they do not require painting at intervals to prevent them rusting. Six-foot lengths which we had an opportunity of testing showed no signs of bending when laid across two bricks and stood upon in the centre.

## CEMENT AND WATERPROOFING MATERIALS.

The stand of the Cement Marketing Co., Ltd. (8, Lloyd's Avenue, London, E.C.3), comprised a comprehensive exhibit of the products of the Associated Portland Cement Manufacturers, Ltd., the British Portland Cement Manufacturers, Ltd., Martin, Earle and Co., Ltd., and the Wouldham Cement Co., Ltd. Samples of the brands of cement manufactured by these companies were shown, and also cement at various stages of manufacture; samples of cement ground to different degrees of fineness; neat cement and cement and sand briquettes of various ages for testing tensile strain, and cubes of various ages and mixtures for testing crushing strength; various samples of aggregates; samples of plaster of Paris, superfine Keene's and Parian cements; and specimens of sacks, casks and drums. Practical tests were carried out on the stand with testing apparatus conforming with the requirements of the revised British Standard Specification, and with a hydraulic crushing machine (for cubes with an area of 50 sq. cm.) reading up to 50 tons—this machine is made by the A.P.C.M. from their own designs.

Messrs. Kerner-Greenwood and Co., Ltd. (King's Lynn), demonstrated the practical application of "Pudlo," the well-known cement waterproofing material. The exhibits consisted of:—(1) apparatus for testing the resistance of cement to the permeation of water under pressure; (2) a section of concrete flooring with a 1-in. "Pudloed" cement top dressing, the lower portion of the slab being immersed in water, whilst the top remained dry; (3) a stoneware drainpipe, jointed with a mixture of 3 parts sand and 1 part cement and "Pudlo," filled with water; (4) a thin tank of porous concrete blocks, with a facing of ¼ in. of "Pudloed" cement applied during the process of manufacture, filled with water. The application of this waterproofing material to damp walls, flooded cellars and damp-courses was also shown.

The advantages claimed for "Novoid" concrete water-, acid- and oil-proofing material were demonstrated by the Torbay and Dart Paint Co., Ltd. (26/28, Billiter Street, E.C.3), in quite a novel manner, *i.e.*, by slides of photomicrographic views of portions of surfaces of ordinary Portland cement and Portland cement mixed with "Novoid." As will be seen by *Fig.* 1, the untreated surface shows a very porous structure, resembling a sponge, whilst the treated cement (*Fig.* 2) shows a very regular surface, resembling granite. The views are 40 times actual size.

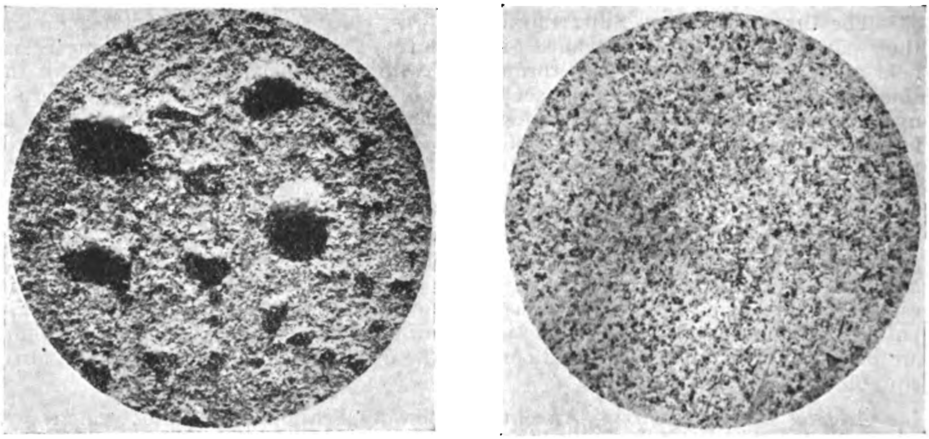


Fig. 1. Fig. 2.

PHOTOMICROGRAPHIC VIEWS OF TREATED AND UNTREATED PORTLAND CEMENT SURFACES.

" Novoid " is in powder form and by amalgamating with the cement causes a chemical action to be set up when the water is added whereby the voids are filled with silicates and the entire mass rendered water and oil proof. Another speciality shown by this firm was " Everok," a colourless liquid hardener which imparts a smooth, impervious surface to concrete.

MESSRS. SUPER-CEMENT, LTD. (71, Lincoln's Inn Fields, W.C.2), gave practical demonstrations of their speciality. Vessels made of Super-cement and sand were shown, and also trays of porous breeze concrete rendered watertight by a mere brushing over the inside with Super-cement slurry. Besides being waterproof, this material claims to be impervious to oil and petrol. The material has been the subject of exhaustive tests, and experiments have been carried out to show that a slab 1 in. thick of one part Super-cement and one part washed Thames sand would resist a continuous pressure of 50 lbs. per sq. in. of aviation petrol for 67 days, at the end of which period the slab was unpenetrated. A similar slab has withstood a water pressure of 300 lbs. per sq. in. for 34 days without any sign of penetration. Super-cement is being largely specified by Government departments for use in work carried out for them.

Preparations for rendering cement surfaces impervious to animal, vegetable and mineral oils and acids were shown by MESSRS. HERBERT FENDER AND CO. (329, High Holborn, W.C.). These preparations, " Recelt " and " Kelasto," have been tested up to high pressures, and are recommended for coating the interiors of large storage tanks ; the latter also prevents the corrosion of metal work.

## REINFORCEMENT.

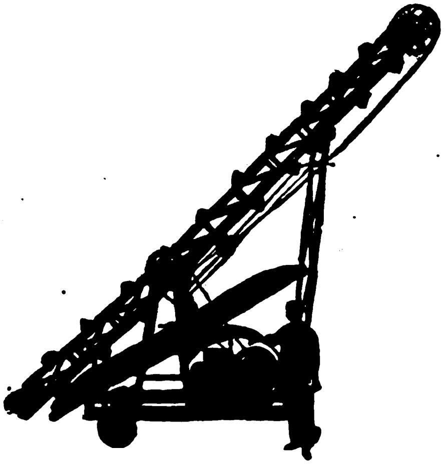
" B.R.C." fabric, which is being so extensively used for road work, and reinforcements for every description of concrete work, were shown by the BRITISH REINFORCED CONCRETE ENGINEERING CO., LTD. (1, Dickinson Street, Manchester). " B.R.C." reinforcement is of a very simple design, and has the added advantage that it leaves very little work to be done on the building site. The numerous photographs which covered the walls of the stand, of buildings in which " B.R.C." products are incorporated, testified to the extent to which this reinforcement is being used ; this was specially noticeable in the photographs of roads " before and after," good roads being formed, without any preliminary work, across country which was previously practically impassable owing to its marshy nature.

MESSRS. JOHNSON'S REINFORCED CONCRETE ENGINEERING CO., LTD. (Lever Street, Manchester), had a comprehensive display of the reinforcements in which they specialise, namely, the " Lattice " and " Keedon " systems of concrete reinforcement and " Brictor " reinforcement for brickwork. These systems are simple and at the same time very efficient. The firm's steel wire lattice is for floors, roofs, roads, etc., while the " Keedon " system is specially designed for beam and column construction. In this system the shear members are fixed to the reinforcing bar by keys, or wedges, thus providing a perfectly rigid and yet adjustable reinforcement.

The Expanded Metal Co., Ltd. (York Mansions, York Street, S.W.1), exhibited samples of their well-known reinforcements and photographs of various works carried out on these systems. Amongst the products of the Company may be mentioned ' Diamond Mesh " expanded steel sheet reinforcement for roads, foundations, walls, floors, roofs, and similar purposes ; expanded metal lathings for interior and exterior plaster-work ; " Exmet " reinforcement for brickwork, concrete block-work, partition slabs, etc. ; and twisted and set steel wall-ties for cavity walls. Sections were also shown of reinforced concrete flooring, stairs, solid and hollow partitions, and reinforced brickwork.

Bar-bending machines were shown by Mr. W. Kennedy (26, Brandville Road, West Drayton, Middlesex), who specialises in this class of machinery. The machines are adapted for either hand or power and are made in various sizes for bending cold square or round bars and cold unloaded tubes. These machines are well designed, compact and made of the best materials. They are particularly suitable for bending steel of the sizes generally used in the reinforcement of heavy concrete work, and are extensively used for this purpose.

## MACHINERY AND PLANT.

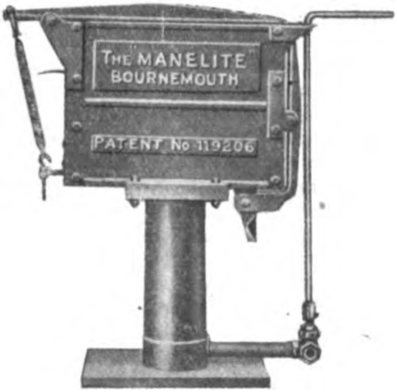


" Winget " Portable Elevator.

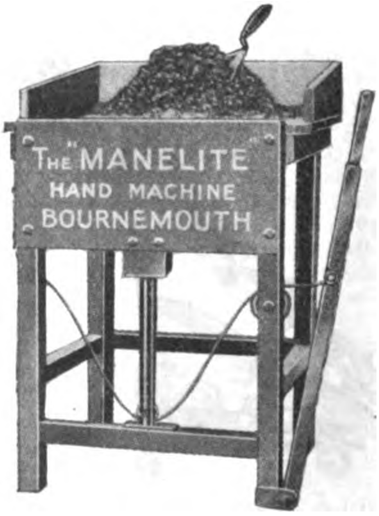
Messrs. Winget, Ltd. (24, Grosvenor Gardens, S.W.), showed an extensive variety of concrete machinery in working order. These included a 32-in. block-making machine, which makes sufficient blocks and slabs in 3½ days for a two-story cottage with an area of 400 sq. ft. ; and a smaller pressure machine, specially dedesigned to meet the growing demand for concrete blocks where light labour only is available and where a wide range of shapes and sizes is not required. The well-known " Winget " chain-spade mixers, for both petrol and electric drive, were also shown. New additions to the concrete machinery manufactured by this firm include a stone-breaker and crusher and a roofing-tile machine. The stone-breaker is constructed on very simple lines, and appears to be a workmanlike and efficient machine. A portable hoist, which not only solves the problem of lifting concrete blocks during building operations but eliminates the costly task of carrying bricks up a ladder in a hod, was also shown. This machine is also suitable for lifting gravel, sand, clinker or similar materials and for emptying such materials into trucks. Fifteen hundred concrete blocks 18 in. by 9 in. by 4½ in., or 5,000 bricks, or over 10 cu. yds. of sand or gravel may be lifted per hour with this elevator, thus effecting an enormous saving in time and labour. The total weight of the elevator is 25½ cwt., and the overall width 4 ft. 6 in. The maximum elevating height is 16 ft. The combined length of the two booms is 20 ft., and the height with the lowest working position is 10 ft. A 3 h.p. Lister benzol or petrol engine is used to provide the motive power.

A large selection of concrete plant was exhibited by Messrs. Vickers, Ltd. (Broadway House, Westminster, S.W.). The portable concrete brick machine for hand power makes six bricks at a time, of standard British or Continental dimensions, plain or coloured. By simple adjustments any thickness of brick, and all types of fancy goods, arch bricks, floor tiles, etc., may be made without additional apparatus. The concrete partition-slab machine makes slabs of varying thicknesses from 2 in. to 4 in. (5·1 to 10·2 cm.). Hollow or solid slabs for partitions or external walls may be made on these machines with square edges or with groove-and-tongue joints. Agricultural pipes can be produced by the use of a special attachment fitted to the partition-slab machine, which admits of the production of three or five pipes with butt joints being manufactured at each operation. The Vickers-Hobbs block machine produces blocks, hollow or solid, on the face-down system. A range of 2,000 different sizes and shapes of blocks can be produced with this machine, and with the special face plates it is possible to obtain a similar natural effect as that produced by dressed stone. The concrete interlocking roofing tile machine is a light portable plant for producing interlocking roofing tiles of any desired colour or surface. Each machine is fitted with an apparatus for rapidly applying an even coat of cement colour to the face of the tile, which is applied dry and trowelled into the surface, thus effectively closing and filling the pores with the colour and rendering it absolutely waterproof. These tiles are one of the cheapest forms of permanent roofing on the market. The doors, windows, gates, dressers, etc., shown on the stand were examples of the standardised joinery now being produced by Messrs. Vickers for supplying the building trade.

New block-making machines, the " Manelite," were shown by Mr. C. J. MANNELL (Petra Place, Poole Hill, Bournemouth). The hand machine, which makes small blocks on end, must surely be one of the cheapest on the market, selling at £24. The mechanism is extremely simple. After the concrete has been tamped, the block is raised by a hand lever at the side of the machine, which pulls a wire rope passing over a pulley wheel attached to the side of the stand and under another wheel at the bottom of rod attached to the bedplate of the mould, and finally fixed to the opposite side of the frame. The movement of the lever raises the bedplate and the block above the level of the mould, ready for removal. In the power machine, the concrete is first tamped by hand, and then with a heavy iron cover. The turning of a rod at the side of the machine simultaneously causes the cover to fly back and raises the block. When the block is removed the bedplate of the mould automatically sinks into position. These blocks are also made on end, with interlocking joints.



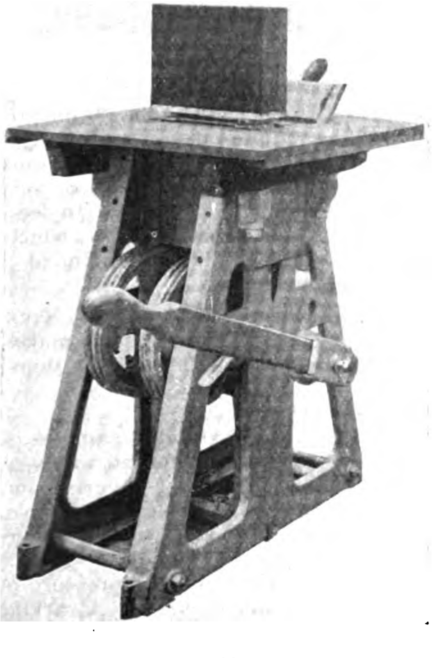
THE " MANELITE " POWER MACHINE.



THE " MANELITE " HAND MACHINE

The RANSOME-VERMEHR MACHINERY CO., LTD. (14/16, Grosvenor Gardens, S.W.), had a good display of concrete machinery. The " Ransome " concrete mixers are in use all over the world, and have many operating advantages for enabling the maximum output to be obtained in the shortest time at the least expense. There are models and sizes for all purposes. The "1920" Ransome concrete street mixer, having distributing boom, automatic discharging bucket and self-propelling road wheels, was also on view. The "Ransome" hand barrow is mounted on two large diameter wheels, and is balanced in such a way that the load falls on the axle instead of the handle. Although its carrying capacity is three times greater than that of an ordinary barrow, on account of the scientific balance it is when fully loaded as easily hauled by a boy as an ordinary barrow is by a man. Other Ransome exhibits included a quick-tipping wagon, mounted on 24 in. gauge wheels; the "Ransome" type "D" steel piling—this is a combination of lightness and great strength, is watertight, easily driven and extracted, may be used repeatedly, and was used on the Rosyth Naval Base; and a "Ransome" pile helmet, for the rapid and economical handling of concrete piles.

The handy and efficient "Australia" block-making machine, shown by the **Australia Concrete Block Machine Syndicate, Ltd.**, of 608, Salisbury House, E.C.2, was described and illustrated in our March issue. This machine is being extensively adopted for use on housing schemes, on one of which, after tests extending over two months, including periods of very bad weather, it is being used exclusively for the concrete slab work. Houses erected in Australia several years ago of blocks made with this machine are, we understand, giving complete satisfaction, although built on a sea wall and exposed to gales and sea air. In an 8-hour day 430 blocks can be turned out by an experienced man.

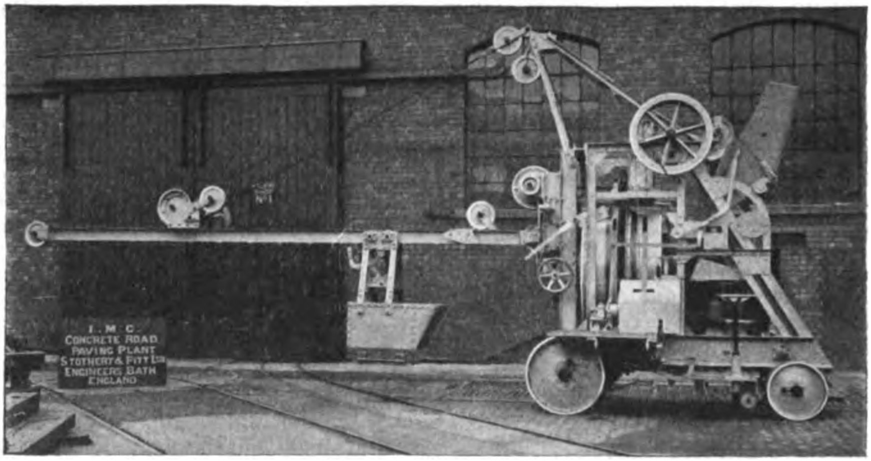


"Winch" Block-Making Machine.

Another new block-making machine, the "Winch," was shown by Mr. C. F. **Cole** (Alperton, Middlesex). This machine is very strongly and simply designed. The blocks are made on end and raised by a hand lever at the side of the machine which actuates a wire rope over a large winch wheel. From the winch wheel the rope passes over a small pulley wheel near the top of the machine and is fastened to the bed-plate of the mould. An advantage of this type of machine is that there are no cogs in which grit might accumulate and temporarily stop its use whilst it is being cleared.

Concrete block and tile making machines, both for hand and power, and mixer, were shown by **Mr. Henry Wilde** (8, Manor Park, Lewisham, S.E.). One of the most interesting machines shown was a power tamper working over a block-making machine. Each tamper foot strikes 70 blows a minute, each blow having a pressure of 700 lbs. This machine can be adapted to operate with any form of hand block-making machine, and, besides being a great labour-saver, its use results in uniform blocks of great density. The tilemaking machine was built on novel lines. The concrete is passed through rollers at the top end of the machine to obtain the thickness required, and as it is carried along a moving platform a coating of colouring material is automatically shaken on to it from a box suspended above the platform. The tile is then passed through other rollers, which press the colouring well into the surface.

The chief exhibit of Messrs. Stothert and Pitt, Ltd. (of Bristol and London), consisted of one of their "No. 1 Victoria" concrete mixers mounted on a self-propelling truck and fitted up as a road paving plant. The mixing drum is built on standard lines, but it is mounted so that it discharges endwise instead of at the side. This arrangement is to enable the plant to be travelled backwards as the work proceeds without interrupting the laying of the concrete on the road. The special feature of the plant is the distributing boom, along which a drop-bottom skip is travelled. The movement is controlled by a clutch gear and can be reversed at will. The boom can be swung to any desired angle, and the skip run out the required distance along the boom. By means of a trip gear the bottom of the skip is released, and the concrete deposited in position. The boom is long enough to sweep from side to side of any ordinary road. The firm's standard loader, with slight modifications, is used to feed the machine. The plant is driven by a twin-cylinder 10 b.h.p. petrol motor, which operates all motions, including the self-propelling gear. The exhibit also included a "Smith" hand-mixer, and a "Dri-crete" block-making machine.



Stothert & Pitt's Road-Making Plant.

The "Kirk" concrete block-making machine was shown by Messrs. R. H. Kirk and Co. (Collingwood House, St. Peter's, Newcastle-on-Tyne). This machine makes slabs up to 5 ft. in length, and is specially adapted for the manufacture of sills, steps, copings, etc.

### ROOFING MATERIALS.

The Ruberoid Co., Ltd. (81/83, Knightrider Street, E.C.), exhibited samples of "Ruberoid" roofing materials, which have been extensively used for all kinds of building work for many years past. This material, which is suitable for covering and weatherproofing roofs of any shape or material, is very economical, durable and reliable. The material is now made in two colours, red and green. Its application to various types of roofs, gutters, flashings, etc., was demonstrated by means of models. "Ruberoid" damp-courses are of a bituminous material which is unaffected by pressure or temperature and fulfils all the requirements of a permanent damp-course. A sarking felt, made of the same materials, is widely used for use under slates or tiles, especially on buildings in exposed positions. "Pluvex" is a self-finished bituminous roofing for temporary structures.

All classes of roofing, sarking and lining felts and damp-courses were shown by Messrs. D. Anderson and Son, Ltd. (Lagan Works, Belfast). On the stand were models showing a "Belfast" lattice girder roof covered with "Rok" self-finished bituminous roofing; a roofing showing "Stoniflex" and "Sanador" felt used under slates; and "Ferro-Rok" corrugated sheets and wood fencing treated with "Sideroleum" wood preservative. Especially interesting was a tank lined with bitumen sheeting and containing two sections of brickwork standing in water. The upper part of the brickwork was protected from the rising dampness from the water by Anderson's damp-course, and the fact that no moisture found its way past the damp-course is incontrovertible proof of its efficiency.

### GENERAL.

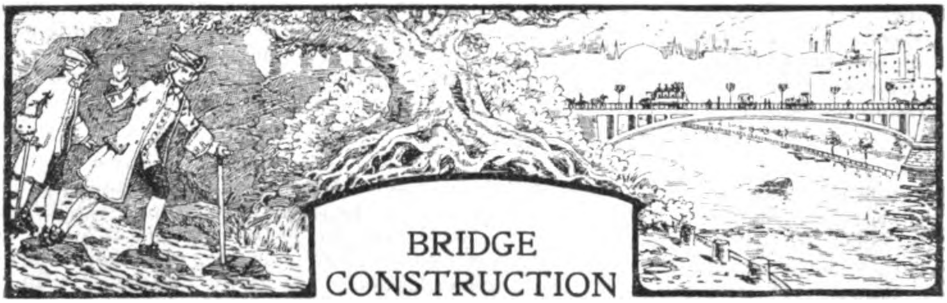
Messrs. Building Products, Ltd. (44/46, King's Road, Sloane Square, S.W.3), exhibited "Rigifix" bolt-hanger sockets and slotted inserts, and various preparations for waterproofing and hardening concrete. The slotted inserts and sockets are intended for fixing into concrete beams during the process of moulding in order to carry pulleys, shafting, etc., thus eliminating the necessity for cutting the finished work. "Bareau," the new cement waterproofing powder manufactured by this firm, "Prufit" waterproofing paste, "Ferrolithic," a metallic hardening and oil-proofing material, and a preparation for applying to moulds in concrete work to ensure easy withdrawal were shown, as was also a bench machine for bending reinforcement rods.

The British Steel Piling Co. (Dock House, Billiter Street, E.C.) exhibited their well-known steel sheet piling, pile-driving machinery, steam, electric and petrol-driven friction winches, and concrete mixers. The "Zenith" winch is equally suitable for pile-driving, hoisting, hauling, well-sinking, and similar purposes, and is an indispensable machine for contractors, shipbuilders, etc. It is very strongly and compactly built and can be driven by any motive power. Such labour-saving machines as these, by eliminating costly manual labour, pay for their initial cost over and over again on a big contract. The firm make every description of plant for pile-driving operations, and have a large staff of experts on the subject whose services are at the disposal of engineers and contractors who are undertaking or contemplating such work.

The stand of Messrs. Sharp, Jones and Co. (Parkstone, Dorset) contained a remarkable assortment of concrete tubes and sewers. These are now being used more and more extensively for sewers and pipelines, and this stand, displaying as it did sections of tubes up to 6 ft. in diameter, demonstrated the possibilities of concrete in this direction. The firm are now making curved pipes for angles, thus dispensing with the practice of running one pipe into a chamber from which another pipe runs off at right angles. There were also shown concrete junctions, radials and tapers, an outlet piece with tide valve, a sewer manhole with a patent "Aquatite" foundation piece comprising pipe connections, channelling, and benching, seating slabs for manhole covers, roofing tiles and reinforced concrete sleepers.

Patent flooring systems were shown by the Siegwart Fireproof Floor Co., Ltd. (231, Strand, W.C.2), in which a series of granite-concrete beams, reinforced with steel bars, are placed side by side and jointed; by the Kleine Patent Fire-Resisting Flooring Syndicate, Ltd. (133/136, High Holborn, W.C.), consisting hollow-brick beams, especially designed for floors where timber centering cannot advantageously be used; and by Messrs. Homan and Rodgers, Ltd. (17, Gracechurch Street, E.C.), in which hollow concrete bricks, with a top-dressing of cement, are used.

Among a large number of exhibits of heating apparatus, the "Interoven" stove, shown by the Interoven Stove Co., Ltd. (156, Charing Cross Road, W.C.2), was specially interesting. This stove is aptly called "two stoves in one," fulfilling as it does the purpose of a handsome sitting-room grate or a kitchen range. The conversion from the one to the other is a very simple matter, and the operations are practically fool-proof. The average coal consumption is 2 lbs. per hour. The cooking capacity is equal to a much larger stove, and meals for eight or ten persons can easily be cooked on it. It is provided with an extra large hot-plate and a hot-closet under the fire. The boiler can be heated with either an open or closed fire, and has a capacity of 35 gallons. This combination is specially recommended for use in cases where large houses are being converted into flats, as it is readily adaptable to any existing fireplace.



# BRIDGE CONSTRUCTION IN REINFORCED CONCRETE.

By Prof. E. R. MATTHEWS, Assoc.M.Inst.C.E., F.R.S.E., University of London.

*Generally.*—There is a saving in cost of about 10 % to 12 % by using reinforced concrete instead of steel in the construction of bridges. The material has been very extensively used for this purpose in America, and on the Continent, and some very excellent examples may be seen, including several large-span bridges. One of the best examples of these is the Gruenwald Bridge at Munich, the centre spans of which are 229 ft., with a rise of 42 ft. This bridge when completed was the largest reinforced concrete bridge thus far built. The bridge consists of two centre spans arched, and five 28 ft. girder approach spans. The roadway, including footways, is 30 ft. wide.

The thickness of the arch-ring at the crown is 30 in., and at the springing line 48 in. The reinforcement of the arch ring consists of 28 steel rods 1·1 in. diameter placed half at the top and half at the bottom of the ring. Round steel bars were used, and they were tied together every 3 ft. with ¼-in. wire. Various types of reinforced concrete bridges are shown in *Figs.* 1–4.

*Methods of Reinforcing Arches.*—The arch must be considered to be a beam subject to either positive or negative bending moments, and it must therefore be reinforced top and bottom. The shearing stresses are so small that they may almost be disregarded. The inner and outer reinforcement must be tied together as the arch is subject to severe compression.

*Advantages of the Reinforced Arch.*—The chief advantages are :—

(1) In ordinary masonry or concrete arches tensile stresses must not occur, and the arch-ring must be so designed that the line of pressure will fall within the middle third of the ring ; in reinforced arches this is not necessary, for the arch-rib is a beam, and can be designed so that it may carry heavy bending moments which involve tensile stresses in the steel.

(2) Bridges of the arched type are rigid, light, and strong.

(3) The expansion and contraction is very little.

(4) Reinforced concrete bridges generally cost nothing in upkeep.

*Design of Arch Ring.*—This may be done graphically, or by calculation, or by both methods. We will deal with it by calculation in a typical example we

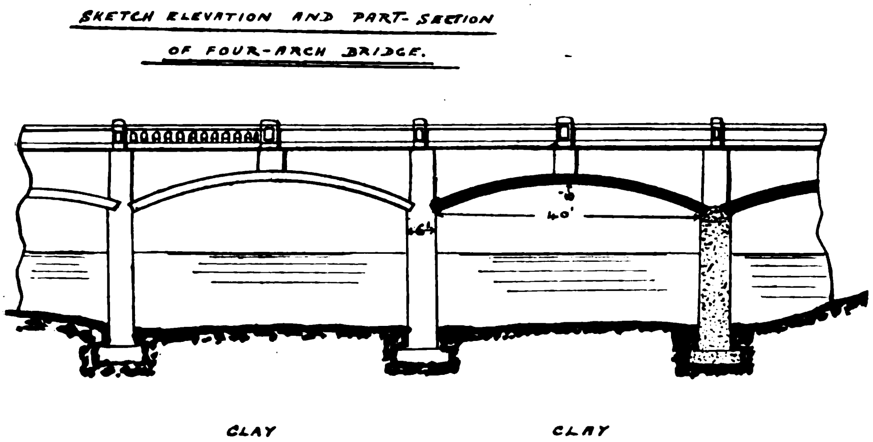


Fig. 1.

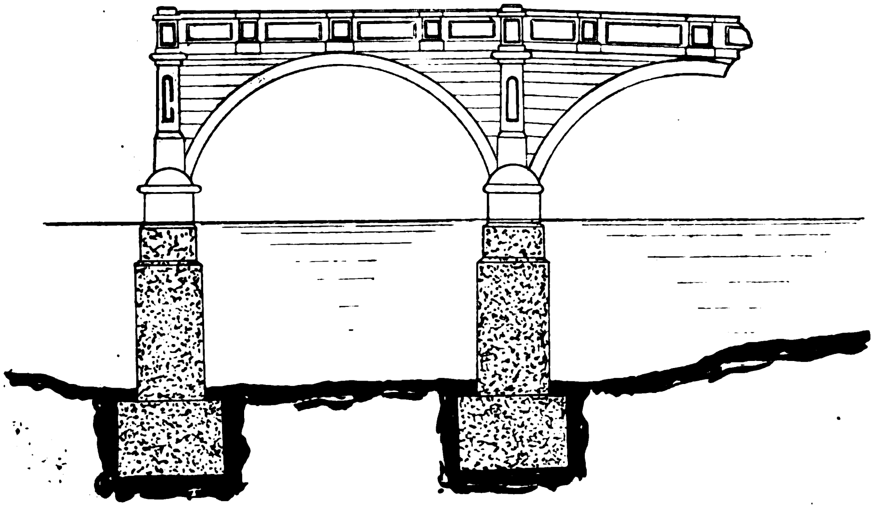


Fig. 2

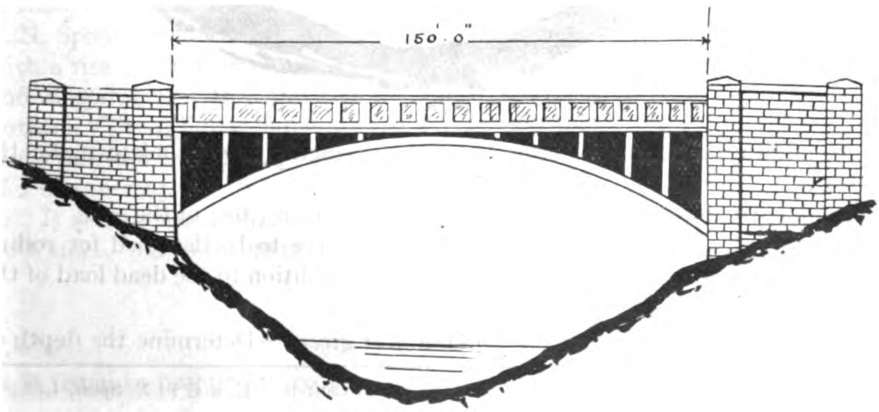


Fig. 3.
Various Types of Reinforced Concrete Bridges.

are about to take. The span being fixed, it is usual to assume a certain depth of arch-ring, and an experienced designer can tell within 2 in. or 3 in. the necessary depth. The arch is usually (but not always in small spans) thicker at the springing line than at the crown.

The depth at the crown may be checked by the formula :—

$$d = \sqrt{S} + 0{\cdot}1S + 0{\cdot}005w + 0{\cdot}0025w^1$$

where $d$ = depth at crown in inches.
$S$ = clear span in feet.
$w$ = average load in lbs. per sq. ft. on the arch.
$w^1$ = dead load in lbs. per sq. ft. above the crown.*

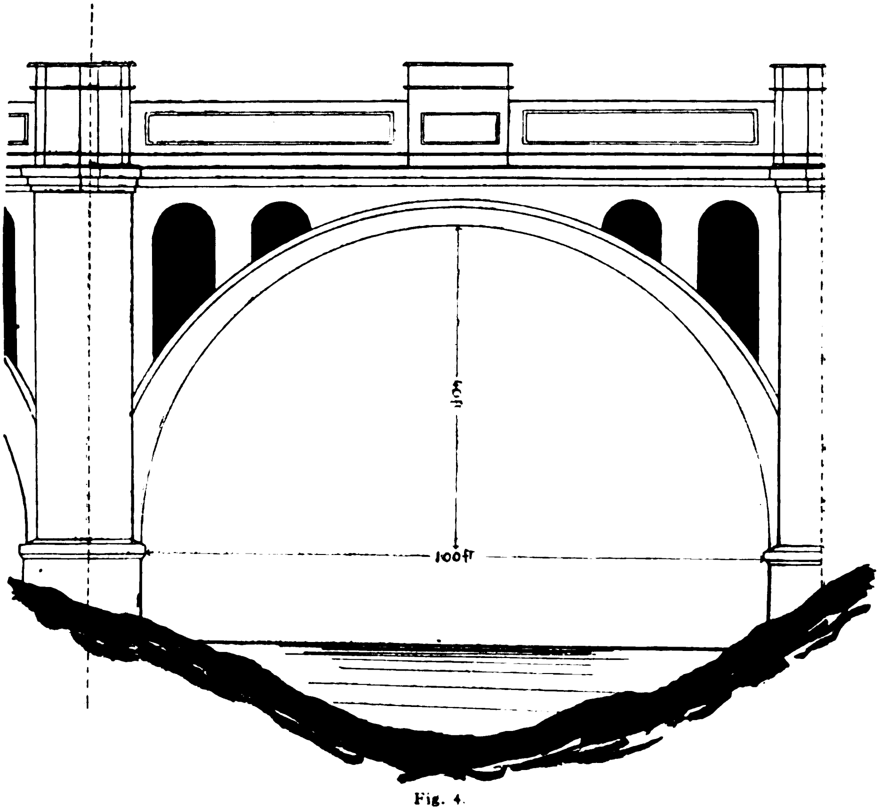


Fig. 4.

At midway between the crown and the springing it is usual to make the depth $1\frac{1}{8}d$.

Frequently in segmental arches the rise varies from $\frac{1}{5}$ to $\frac{1}{8}$ of the span.

Reinforced concrete arches in road bridges have to be designed for rolling loads, such as steam rollers, heavy lorries, etc., in addition to the dead load of the filling, and the weight of the structure itself.

*Typical Example based on the formula just given:*—Determine the depth of arch necessary for a clear span of 40 ft., the live load to be supported being equivalent to 200 lb. per sq. ft. over a length equal to the span.

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* *Reinforced Concrete Construction* (Advanced), by M. T. Cantell. (E. and F. N. Spon, Ltd.)

Assume the rise of the arch as $\frac{Span,}{5}$ this will equal 8 ft. By the formula just given, the depth of the arch at the crown will be :—

$$\sqrt{S}+0{\cdot}1S+0{\cdot}005w+0{\cdot}0025w^1$$

Take the filling at the crown to be 2 ft. deep, with an average depth of 3 ft., at 100 lb. per cu. ft., $w$ will equal $100\times3=300$, $w^1=200$, therefore

$$d=\sqrt{40}+0{\cdot}1\times40+0{\cdot}005\times300+0{\cdot}0025\times200=12{\cdot}32 \text{ inches};$$

and $d$ at $\frac{1}{4}$ span $=1\frac{1}{3}\times12{\cdot}32$, say, 16·43, say 16·5 in. at $\frac{1}{4}$ span, and 22 in. at the springing.

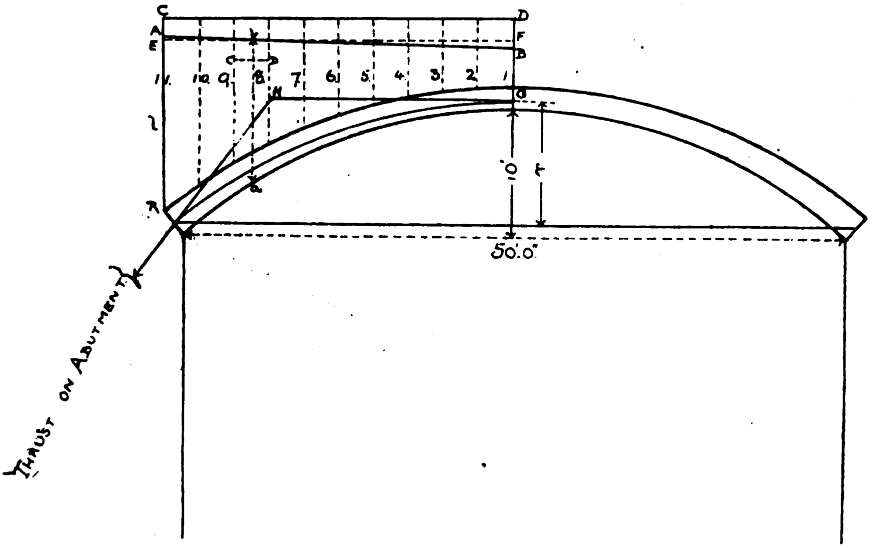


Fig. 5.

*Example.*—We will now take a modified example of that given on page 182 in *Reinforced Concrete Construction* (Advanced Course), by M. T. Cantell (E. and F. N. Spon). Determine the stress in a segmental arch over a clear span of 50 ft. with a rise of 10 ft. (see *Fig.* 5). The thickness of the arch at crown being 1 ft. and at springing 2 ft.; the arch is reinforced with six 1 in. round rods top and bottom. The filling is horizontal, and 3 ft. deep above the crown, and it consists of earth weighing 100 lb. per cu. ft. Allow for a uniformly distributed super-load of 2 cwt. per sq. ft.

It is only necessary to consider one side of the arch as the load is the same on both sides. As to the magnitude of this load, it consists of :—

(*a*) The weight of the arch.
(*b*) The filling.
(*c*) The super-load.

It is usual in practice to reduce this load to the same density as concrete, and this can easily be done in the following manner. The superload we said was 2 cwt. per sq. ft., or 224 lb.; this is equivalent to 2·24 ft. depth of filling, making the total depth of filling

$$2{\cdot}24+3=5{\cdot}24$$

above the crown. *AB* (in diagram, *Fig.* 5) represents the level of the filling, and *CD* the increased depth, owing to the super-load. We now reduce the filling to its equivalent weight in concrete, taking the weight of a cu. ft. of concrete at 150 lb., the surface *CD* will then be reduced to *EF* or $\frac{100}{150}=\frac{2}{3}$ its real depth.

The reduced load on the half arch is now divided up into sections; any number may be taken; we will take 10; they are each 2·5 ft. wide, and vary in depth from 1 ft. at the crown to 2 ft. at the springing.

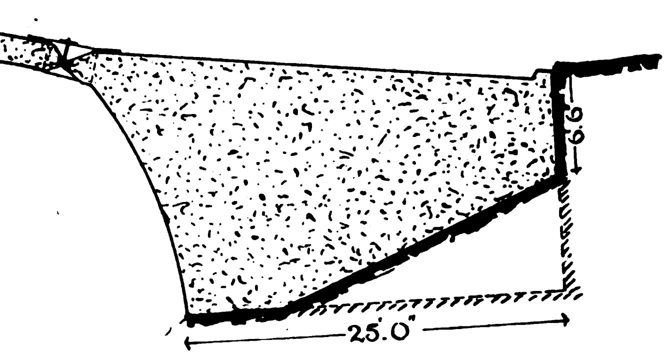


Fig. 7.

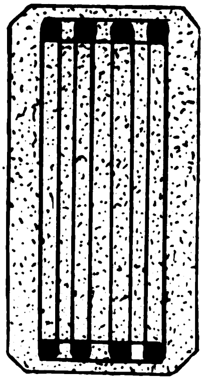


Fig. 6.

We now determine the centre of gravity of the various loads. Each load will equal the mean ordinate multiplied by the width and the weight per cu. ft. Example:—

$$ab \times cd \times 150 \text{ lb.}$$
$$=10{\cdot}5\times2{\cdot}5\times150 \text{ lb.}=3{,}937{\cdot}5 \text{ lb.}$$

The various loads are thus determined, or the total load can be ascertained and divided in proportion to the mean ordinates.

The total load will equal the sum of the mean ordinates multiplied by $2{\cdot}5\times150$ lb.

The sum of the mean ordinates in this case $=83{\cdot}25$,

Therefore $83{\cdot}25\times2{\cdot}5\times150=31{,}218$ lb.

The centre of gravity of the load and the true thrust can be determined by calculation or by the construction of funicular diagrams. We will arrive at these by the former method, and must proceed as follows:—

(1) Divide the load on the half-arch into a convenient number of parts and find out the weight of each, or the area of each. This has already been done.

(2) To determine the centre of gravity by taking moments about any base line, multiply each load by the distance of its centre of gravity from the base line then add the whole together, and divide their sum by the sum of the loads; the result will equal the distance of the centre of gravity from the base line.

The most convenient base line will be a vertical from the centre of the skew-back, as this will give us the distance $l$ direct. We can then determine the thrust:

$$T=\frac{Wl}{r}$$

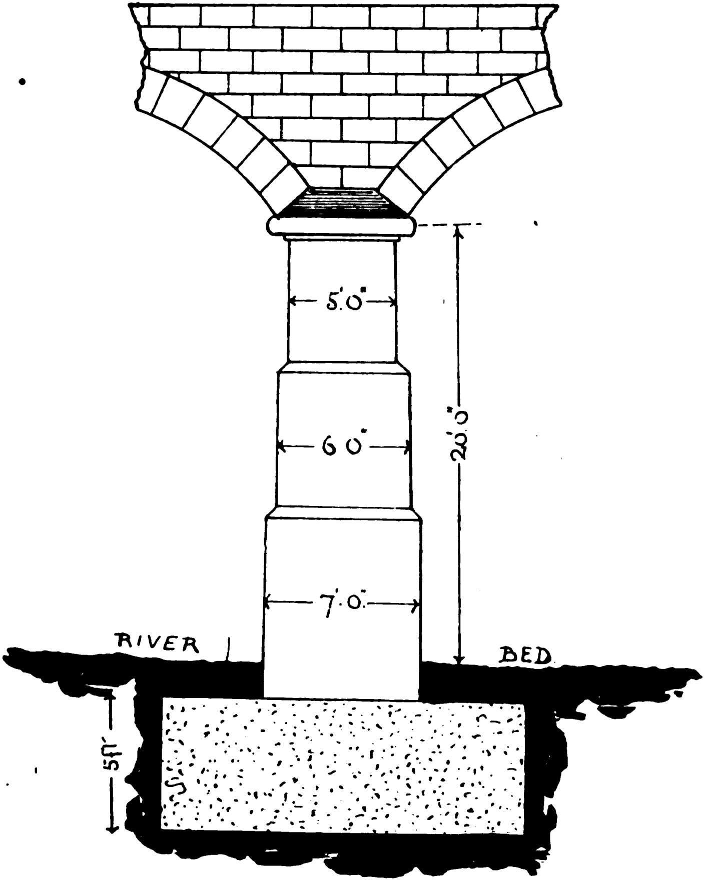


Fig. 8.

In the example we have given we have already divided the half-arch into ten sections, and determined the mean ordinate of each. We now take moments about the line $ER$; then the distance of the centre of gravity from $ER$ it will be found $=8{\cdot}5$ft. $ER$ is 1 ft. from the centre of the skewback, so that

$$l=8{\cdot}5-1{\cdot}00=7{\cdot}5 \text{ ft.}$$

$$\text{Then the thrust}=\frac{Wl}{r}=\frac{31{,}218\times 7{\cdot}5}{10}$$

$$=23{,}413 \text{ lb.}$$

The shear stress is determined in the same way as for a beam.

The thrust being known, and the amount of eccentricity, the arch is then designed by the formula for doubly-reinforced beams ; a typical section through such a beam is shown in *Fig.* 6.

The bending moment will equal the thrust multiplied by the distance in inches it is acting from the centre line of the arch-ring.

In designing railway bridges a height of 10 ft. multiplied by the length of bridge is added to the surface area to represent a train passing over the bridge.

The Board of Trade regulations stipulate that allowance shall be made for a maximum normal wind pressure of 56 $\text{lb./ft}^2$.

*Abutments and Piers in Arched Bridges.—Abutments :* The base dimensions of abutments must be such that the total resultant will pass through the middle third of the structure, and the area of the base must be sufficient to allow of a maximum pressure upon the natural foundations of, say, not exceeding 3 tons per sq. ft., but this will depend on the nature of the ground. If on solid rock 4 tons to 6 tons is permissible. Abutments must be able to act through their own weight regardless of any filling, or they may be of reinforced concrete.

If the resultant falls outside the middle third of the wall steel reinforcement to counteract tensile stresses must be inserted, or the wall widened.

The base of abutments is sometimes inclined instead of being horizontal (see *Fig.* 7), so as to make sliding more difficult.

It is extremely important that abutments should be of a heavy type, and well built, as the failure of an arch is usually due to one of these giving way.

In designing abutments it is convenient to begin by using an empirical formula, and the one given in *Reinforced Concrete Bridges*, by Frederick Rings (Constable and Co., Ltd), is useful and reliable.

It is as follows :—To ascertain the thickness $T$ of abutment at point of springing, use the following formula :—

$$T = \frac{r}{5} + \frac{v}{10} + 2$$

$r$ being the radius of curvature in ft., $v$ the versed sine or camber.

*Piers.*—The load on the natural foundations (as in the case of abutments) should not exceed 3 tons per sq. ft. on ordinary compact soil.

The pressure on the concrete foundations and on piers may be as much as 12 tons per sq. ft. The top of the foundations should be below the river bed (as shown in *Figs.* 1, 2, and 8), and the pier if of concrete should be in the proportions of 4 : 2 : 1. In the foundations or the centre of the pier it may be 5 : 3 : 1. In bad ground it is often necessary to pile the foundations, and sometimes it is advisable to sink cassoons.

The thrust from one arch will about balance that from the opposite arch of similar size, the resultant passing through about the centre of the pier. If the pier is a good height, it should be stepped out at intervals to increase the dimensions of the lower parts of the pier, as shown in *Fig.* 8.

# "CONCRETE SHIPBUILDING"

## REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

By ALFRED B. SEARLE.

### CHAPTER XI. (*continued*).

### THE ADVANTAGES AND LIMITATIONS OF CONCRETE.

A MINOR objection urged by those who are not sufficiently acquainted with reinforced concrete is that it must be applied in such quantities as seriously to reduce the capacity of the vessels. In practice the actual thickness of the concrete is quite small, and is relatively much less in larger than in smaller vessels.

It is true that concrete reduces the carrying capacity by about 17 per cent., but this is more than counterbalanced by the reduced cost of construction, maintenance and repairs, and by the greater " life " of the vessels. It has been the experience of owners of concrete barges that though they are heavier than those made of wood, yet because of the smoothness of their exterior they do not require any more power to tow them. The skin-resistance of a reinforced concrete vessel to its passage through the water is slight, owing to the smoothness and absence of projections and joints. Consequently, the question of deadweight does not enter so seriously into the subject as might at first be supposed.

As some concrete buildings are not waterproof, it has been suggested that vessels made of concrete would be too porous. This suggestion is due to a lack of knowledge of the properties of concrete. It is a fact, well known to those who have had the largest experience in the execution of such work, that to produce a mass of concrete of a maximum strength and density the materials must not only be mixed in the correct proportions and in a thoroughly efficient manner, but the finished concrete must be kept saturated with water for some time after it is apparently hard. In order that it may mature properly, concrete requires more water than can be mixed with it before it enters the moulds, and this additional water must be supplied by constantly wetting the surfaces of the structure. In the construction of concrete vessels it is easy to immerse them as soon as they are sufficiently strong, and the immersion actually improves the concrete. If attention is paid to the correct grading and preparation and placing of the concrete, there is no serious danger of concrete vessels being porous. Indeed, the perpetual contact with sea-water tends to fill up any pores which may have been due to careless workmanship, making the vessel stronger instead of weaker after several years of use. It should, of course, be understood that the proportions of cement and other materials are not the same in concrete vessels as for work which is for use on dry land ; the conditions to which concrete vessels are subjected are much more severe, and require the concrete to have somewhat different properties.

In their haste to break records, some American barge-builders have overlooked the necessity of using a properly prepared concrete, with unfortunate results. Such cases of carelessness or ignorance are bound to occur from time to time, but they do not in any way detract from the real value of concrete for barge building.

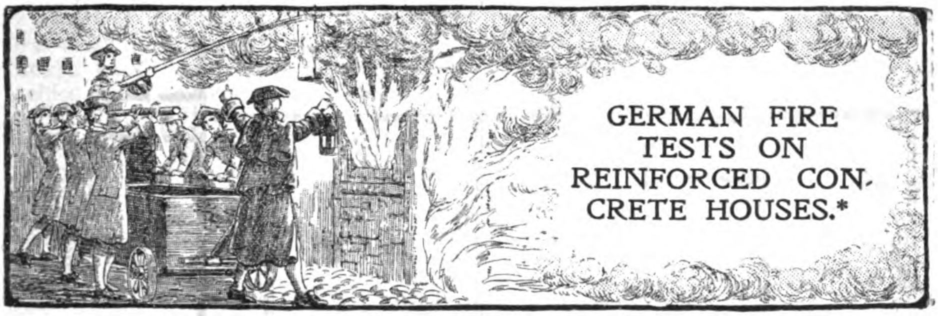
The care needed in connection with the details of construction is very great, as some small and apparently unimportant defects are liable to become serious after the vessel has been in service for some time. The mechanical and chemical action of sea-water on all materials exposed to it is very severe, and in the case of material such as concrete no pains should be spared to secure first-class workmanship and the avoidance or correction of defective construction, or serious difficulties due to cracking, scumming, corrosion, etc., may arise and cause the vessel to deteriorate very rapidly. When it is remembered that too dry or too wet a mixture of concrete will cause failure, and even the incorrect placing of the concrete in the forms may have serious consequences, it will readily be realised how important are the smallest details of construction, and it is easy to show that false economy has been the cause of serious failures in concrete construction on land, though, fortunately, there have been no such failures with concrete vessels. For instance, in concrete structures on land, the contractors frequently restrict themselves unduly with regard to the quantity of shuttering timber they employ in order to reduce the cost of building, and the workmen are urged to remove the forms as soon as possible and do so prematurely, with the result that the concrete does not attain its maximum strength. The use of weak or insufficient forms and shutters is attended by similar difficulties, and is especially dangerous in shipbuilding, as any collapse which might take place would be very serious.

It will therefore be seen that it is most desirable to employ workmen who are sufficiently interested and skilled to carry out each detail of the work with the requisite care. Where a less satisfactory class of labour must be employed, very careful supervision is necessary, and highly skilled men are essential for controlling various operations. This disadvantage must not be over-estimated, and with reasonable care in the selection of men—both supervisory and manual workers—it offers far less difficulties than the employment of the much larger number of highly skilled men which is necessary in other methods of shipbuilding. Most of the skill required in the placing of the reinforcement and the concrete can be rapidly acquired by any intelligent man, and the supervisor has merely to see that such men duly carry out their instructions.

What is, perhaps, the most serious objection to concrete is the difficulty experienced in making small alterations; but this only arises when some oversight on the part of the designer or builder has occurred. It is not really a serious objection to the skilled naval architect, as it can be avoided by paying sufficient attention to the details in the drawing office.

It is very interesting to note that none of the " mysterious " failures which occur in other constructional engineering work have, as yet, been reportedin connection with concrete ships. Hence, most of the technical objections against the use of concrete as a structural material for ships are either imaginary or can be overcome by proper care in manipulation.

Whilst it is not suggested that concrete vessels are likely to replace those used for trans-Atlantic traffic, there is ample justification for its employment in many localities—especially in tropical and semi-civilised regions—for the development of coastal or lacustrine trade more rapidly than would be possible if it is necessary to wait until steel vessels can be supplied. Moreover, in such " out of the way " localities, the case with which concrete vessels can be repaired confers many important advantages, and for such purposes the use of concrete vessels may be highly commended.



# GERMAN FIRE TESTS ON REINFORCED CONCRETE HOUSES.*

By ARTHUR HOLMES, D.Sc., A.R.C.S., F.G.S.

*Geological Department, Imperial College, South Kensington; Technical Assistant to the British Fire Prevention Committee.*

*The illustrations in this article are reproduced from the report on the tests mentioned in the footnote on this page.—ED.*

THE German Committee for the study of reinforced concrete began systematic fire tests during 1910, and the following year, stimulated by the burning of a large warehouse in Dresden, they proposed a new plan of work, and discussed the possibility of making investigations on much larger test-buildings than had previously been used. Two old houses on which tests had been carried out had completely broken down, and it was therefore decided to make the new tests on new houses which were to be specially prepared for the purpose. Elaborate precautions were taken to avoid errors of design and method that former experience had revealed. Among the errors alluded to were: (1) inadequate connection of the reinforcement in the corners of rooms; (2) dampness of the concrete during tests; and (3) insufficient approximation to practical conditions.

The dimensions of the test-houses, known respectively as III. and IV., were 8 metres high by 4 metres by 4 metres, broken basalt and granite being the chief coarse aggregates respectively employed in their construction. Plans and sections of House IV. are reproduced in *Fig.* 1, and its general appearance is shown in *Figs* 2 and 5 (*see next issue*).

**Construction.**—Each house was built in two storeys with a staircase leading from the lower to the upper floor; and each was surmounted by four interlocking arches of equal span supported by strongly reinforced ribs springing from the cornice of the upper storey. The roof so formed was penetrated in each case by a central opening 60 cm. square. Two box-like structures, each 4 metres high, were added to the northern and western walls of House III., and closed off with sloping roofs, one in plain and the other in reinforced concrete. Similar structures were added to three of the walls of House IV., two having a plain covering and one reinforced. These were to be filled about half-way up with readily inflammable material. The windows, of which there were four above and three below in each house, were partly closed with wooden shutters in the upper storey, and fitted with wired-glass (House III.) or block-glass (House IV.) in the lower storey.

The nature and distribution of the various types of concrete and other materials employed were as follows:

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* Brandproben an Eisenbetonbauton, 1914–15. II. Bericht, Erstattet von Prof. M. Gary. Deutscher Ausschuss für Eisenbeton, Heft 33, pp. 66. Berlin, 1916.

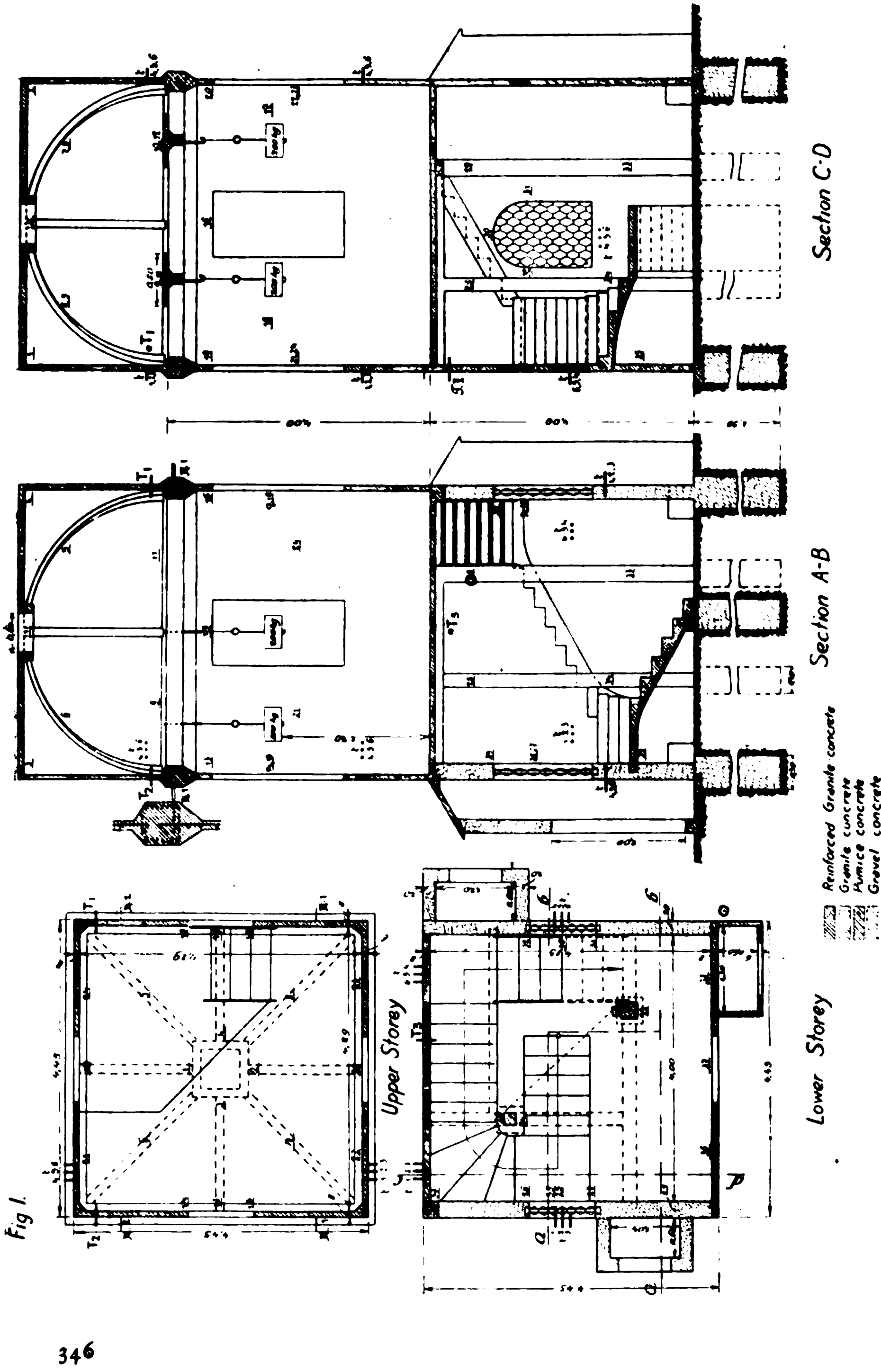


FIG. 1. HOUSE IV.

### HOUSE III.

| | |
|---|---|
| Gravel Concrete, 4 : 1 | Foundations |
| Broken basalt (3–1 cm.), 4; basalt chips (1 cm. down), 4; cement, 1 | Lower storey: west and south walls and box, 20 cm. thick. Floor of upper storey |
| Basalt chips (1 cm. down), 4; cement, 1; (reinforced) | Lower storey: north wall, 10 cm. thick, and box 6 cm. Upper storey: all walls, 8 cm. thick. Roof: interlocking arches. Staircase supports |
| Brickwork | Lower storey: east wall, 25 cm. thick |
| Sandstone | Six upper steps of staircase |
| Artificial stone | All other steps of staircase |
| Siemen's wired-glass panes | Windows of lower storey |

### HOUSE IV.

| | |
|---|---|
| Gravel concrete, 4 : 1 | Foundations. Lower storey: east wall and box, 25 cm. thick |
| Broken granite (3–1 cm.), 4; granite chips (1 cm. down), 4; cement 1 | Lower storey: west wall and box, 20 cm. thick |
| Granite chips (1 cm. down), 4; cement, 1 (reinforced) | Lower storey: north wall and box, 8 cm. thick; south wall, 8 cm. thick; upper storey: all walls 8 cm. thick. Floor of upper storey. Roof: interlocking arches. Staircase supports and pillars, and steps below first landing |
| Crushed pumice, 5; cement 1 | Roof: one of the interlocking arches |
| Blast furnace slag, 5; cement, 1 | Roof: one of the interlocking arches |
| Block-glass panes | Windows of lower storey |
| Square steel girders | Two beams at level of the cornice of the upper storey |
| Sheet of wrought iron | Staircase: steps from first landing upwards |

**Preparations for the Tests.**—The houses were constructed during the spring and summer of 1913, and each was covered with a protecting canopy of roofing felt as a safeguard against rain. These were removed before the actual tests, which were commenced in October of the following year. The objects of the tests were:

(1) To determine the ability of the houses to withstand the effects of fire generally;

(2) To measure the conductivity of heat of various materials;

(3) To compare the crushing strength of different types of concrete before and after firing;

(4) To determine the loss of strength of various materials during and after the fire;

(5) To observe the behaviour of the structures during demolition: and generally

(6) To observe the action of fire on window fittings, walls, arches, beams, steps, etc.; the condition of each kind of concrete and brickwork; fractures, saggings, liberation and effects of water, damage due to falling weights, etc., etc.

The upper storey of each house was first to be fired. The floor was piled up with cleaved logs of pine-wood to a height of 3 metres, and between them shavings were packed, the whole being finally drenched with petroleum. It was also arranged that as soon as the shutters were burnt more wood could be added if necessary, by means of a fire-escape placed against the windows. To ensure adequate preliminary ventilation during the fire, air-holes were placed in the east and west walls by piercing the latter and fitting in furnace bars. From the beams of the upper storey wires were hung supporting weights of 200 kilograms each at a height of 220 cm. from the floor. These were to fall during the fire by the snapping of the wires. To measure the expansion of the beams, iron rods were cemented to the cornice at each end, and their outward movement was to be observed through a telescope. Unfortunately smoke prevented exact measurements being made, and only those of House IV. proved to have any value. Thermo-elements $T_1$ and $T_2$ were carried through the gable walls above the cornice in order to measure temperatures during the fire. At thirty-nine different points on walls, pillars, under the floor of the upper storey, over the beams, and in other places, fire-resisting receptacles, each containing a series of alloys of known fusion-points, were also fixed. With a view to making comparison of crushing strength, cubical test-pieces were cut out of the walls of each house before the fire, and a corresponding set was similarly obtained after the fire.

The first fire was to last 1¾ hours, and forty-eight hours later, while the floor of the upper storey was still weakened by the first fire and under stress from its burden of débris, a second fire similarly prepared was to be started in the lower rooms, and again allowed to proceed for 1¾ hours. In this case temperatures were measured by the thermo-element $T_1$ of the upper storey, by an additional thermo-element $T_3$ carried through the south wall below the floor of the upper storey, and by the fusion of the alloys mentioned above. Before firing the lower storey the 200 kilogram weights were rehung from the cornice-beams.

*(To be continued.)*

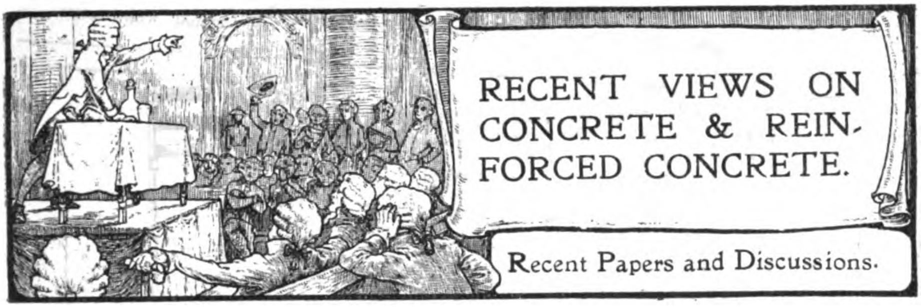
## MEMORANDA.

**United States Bureau of Standards.**—Some interesting experiments have been carried out by the United States Bureau of Standards, and we give below the summary of the tests carried out with reinforced concrete, cement drain, and concrete oil tanks :—

*Reinforced Concrete.*—Work of a preliminary character has been carried out in the flat slab investigation. A slab, 25 by 20 ft., similar in construction to the main slab to be tested, was subjected to a load test which was carried to the destruction of the slab. The slab was built to fail under a live load of approximately 200 lb. per sq. ft. and 65 lb. per sq. ft. dead load. The first load applied was 97 lb. per sq. ft., and the next application 191 per sq. ft., but before the last loading was completed the centre deflection had increased to such an extent as to be more than double that allowed by the most liberal city building codes. The under side of the slab was very badly cracked. Computations of the stresses developed in the steel reinforcement indicated that the rods in the middle third of the short span had been subjected to stresses far beyond the elastic limit of the steel, while in the middle third of the long span the rods had practically reached the elastic limit. Examination of a number of rods appears to indicate that failure by bond did not enter into the final failure, which seems to have occurred under tension, as was indicated from the design computations.

*Cement Drain.*—The field inspection of cement drain tiles in alkali soils is being continued. Several plants for the manufacture of this class of materials have been inspected and the subject has been fully discussed. Samples of tile which had been in place for 12 years at Delta Col., together with samples of water to which it had been subjected, were obtained, and will be used in an investigation to be conducted in the laboratory. The field inspection work for the year has been practically completed, and from the data obtained laboratory investigations will be carried out to find means for producing concrete capable of withstanding alkali action.

*Concrete Oil Tanks.*—Continued observations on tanks under test show no appearance of an increased loss in any of the tanks, and the exterior surfaces of all of them are dry. Two tanks of 1, 1½, 3 concrete have been put under test as oil containers and the observations begun. The first readings will show a much greater loss than subsequent ones, and, consequently, considerable attention is being paid to the first gauge readings, in order to obtain with accuracy the initial penetration losses.



## RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.

Recent Papers and Discussions.

*It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes. Figs. 3, 4 and 5 are reproduced by the courtesy of the Concrete Institute.—ED.*

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### *THE CONCRETE INSTITUTE.*

# STEELWORK IN THE NEW LONDON COUNTY HALL.

### By E. LAWRENCE HALL

*The following is an abstract from a Paper read before the Concrete Institute on March 25th. A short discussion took place afterwards. A short article on the substructure of this building appeared in our pages, Vol. ix., p. 653.*

THIS building is not a steel-frame structure under the 1909 Act, the architectural design requiring such substantial piers of brickwork and stone in the façades to the road and river and to the principal courtyards as to make stancheons unnecessary, and it was decided to build the walls facing the secondary courtyards complying with the Act of 1894, and also to build the corridor walls, in most cases, of sufficient thickness to carry the floors.

The Engineers were also requested to give effect to all the regulations of the 1909 Act, as far as they could be construed to apply, including the pressure allowed on concrete and on the different qualities of brickwork.

In spite, however, of the fact that this is not a steel-framed structure, eight thousand tons of steel has been used, of which the roof and the storeys in it absorb three thousand tons.

It may be well before proceeding to detailed description, to call attention to the Block Plan, *Fig.* 1, showing the division of the scheme into sections A, B, C and D, and the subdivision of these into blocks, Section A consisting of five blocks (Nos. 1 to 5), Section B, four blocks (Nos. 6 to 9), Section C, three blocks (Nos. 10 to 12), and the unbuilt Section D, three blocks (Nos. 13 to 15), which have been designed but are not included in the present contract.

The distinctive blocks are Nos. 1, 3, 5 and 9; No. 1 block is in the centre of the façade towards Belvedere Road and contains the public entrance and waiting rooms and some of the Committee Rooms and is separated by pavilions at each end from the blocks on either side.

Block 3, in the centre of the river front, is in the form of an arc on plan, and also has pavilions separating it from the adjoining blocks. The storeys in the roof of this block are utilised for the Staff Dining Hall and Kitchens.

Block 5 occupies the centre of the site and contains the Council Chamber.

Block 9, with its two corner pavilions, occupies the entire frontage to Westminster Bridge and contains the main entrance leading by a stone vaulted carriageway to the Members' Court.

Blocks 6, 7, 9, 10, 11, 13 and 14 face the road or the river, and have stone façades, while Blocks 2, 4, 8, 12 and 15 face the courtyards and have plain brick fronts, except Blocks 4 and 8, which face the principal courtyard and enjoy more elaborate treatment

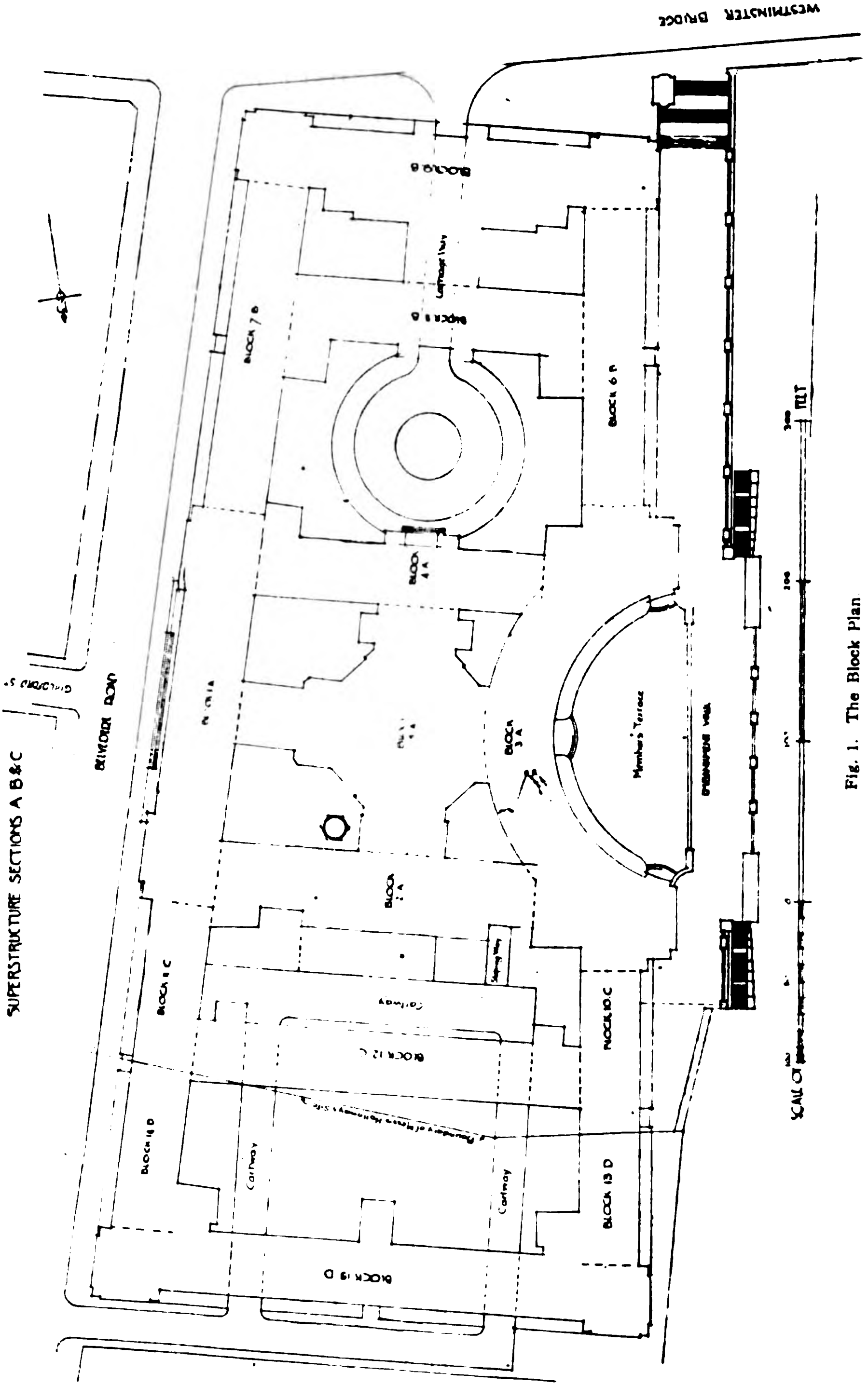

Fig. 1. The Block Plan.
The New County Hall.

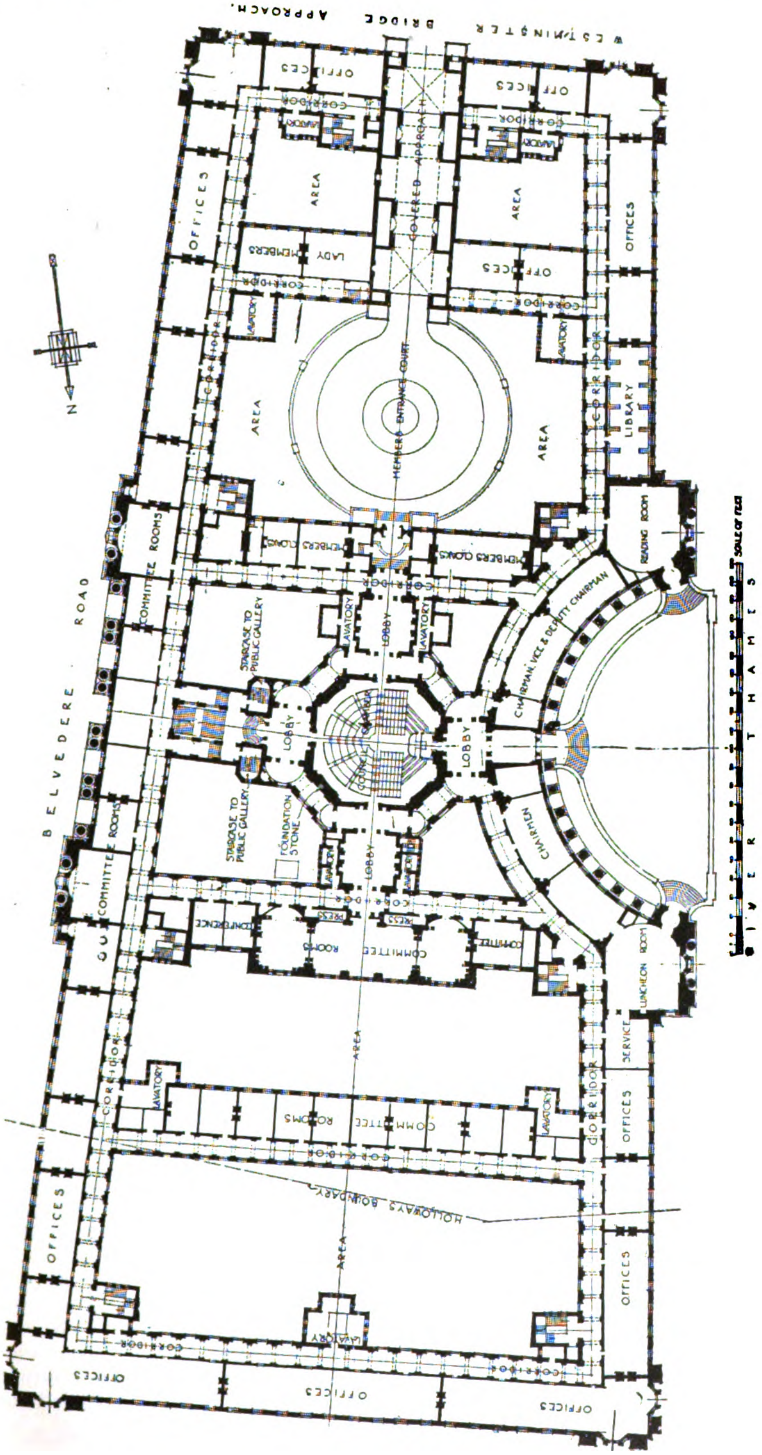

Fig 2. Plan of Principal Floor.
The New County Hall.

*Fig.* 2, a plan of the first (or principal) floor, shows the arrangement in more detail, and it will be seen that the rooms are generally 22 ft. wide and the corridors 10 ft. wide; but above the second floor the rooms are wider and the corridors narrower, the floor girders being in some cases cantilevered over the corridor walls or stancheons.

The flêche is possibly the most interesting feature of the steel frame, from the engineer's point of view, as it is the most prominent feature in the building.

The topmost storey of the flêche, as it may perhaps be called, consists of a vane in the form of a ship standing on a ball supported by four scrolls set on the diagonals, but as this part is to be constructed entirely of teak covered with copper, without recourse to a steel frame, it need not be further described here, except to say that it weighs about seven tons, and is anchored by means of long bolts to the steelwork below.

The next storey, the lantern, is of light steel lattice framing about 23 ft. high, the architectural outline being constructed in teak and clothed with copper. The weight down to this point is about 24 tons.

The third storey down, which may be called the base of the flêche, is 21 ft. square at the base, tapering to 16 ft. 6 in., and is 23 ft. high above the eighth floor level, the topmost 10 ft. being octagonal on plan and the lower part square with projecting faces.

At about one-third the height of this storey the plan is braced by horizontal latticing as shown in *Fig.* 3.

The framing is complicated by the irregular plan and the changes of outline, as well as by the provision of a window in the rear face, added to which the curvature of the plan of the building did not tend to make matters easier, as may be gathered from *Fig.* 4.

The base at the eighth floor is carried on a pair of longitudinal compound girders, framed into two specially heavy roof girders built up of 36 in. webs with angles and flange plates, one end having to be tapered and curved to keep within the outline of the roof, and, for the same reason, the main front longitudinal girder had to be kept 3 ft. below the floor.

The flêche loses itself in the roof at the eighth floor level, but all the framing below is stiffened to carry its dead load of 75 tons and to resist a wind pressure calculated at 40 lb. per sq. ft.

The eaves of the roof of Block 3 are shown. This is the only block in which the rafters are bent to the outline of the tiling. An 8 in. by 4 in. joist, curved on plan, is carried on 5 in. by 4½ in. joist uprights by means of tee cross pieces, and has cast iron stools for attaching the rafters, which are continued down and, in their turn, carry the 6 in. by 3 in. channel supporting the gutter. There is a ventilation duct under the floor, and bulkhead framing, admitting light to the fifth floor corridor windows.

A raking tie anchors the flêche to the fifth floor, opportunity for this being afforded by the double front wall, there being no space in the back wall for any wind bracing, the wall being thin and the stancheons slender.

A similar system of roof girders and wind bracing, but on a lighter scale, is adopted to every bay round Block 3.

This brings the central section of this block down to the level of the fourth floor, between which point and the second floor there is not much of special interest in this section.

The two rear legs of the flêche framing over one of the Lobbies to the Council Chamber are carried on a girder which has also to take the straight end wall of Block 5, and the curved rear wall of Block 3, necessitating a " Y " shape on plan, the axes of the two blocks not being in line. This girder has a web 60 in. in depth and ¾ in. in thickness except to one of the branches of the " Y " which is ⅝ in.

The " Y " girder, with its load of 660 tons, is in turn carried on two box girders which were necessarily shallow and are therefore heavy. Each of these girders has three webs, the central web ¾ in., and outer webs ⅝ in. in thickness by 32 in. in depth, the weight dealt with being some 435 tons on the left girder and 410 tons on the right.

Four stancheons, composed of pairs of 20 in. joists and 18 in. flats, continue this part of the framing down to the ground floor, and it is similarly continued down to the raft.

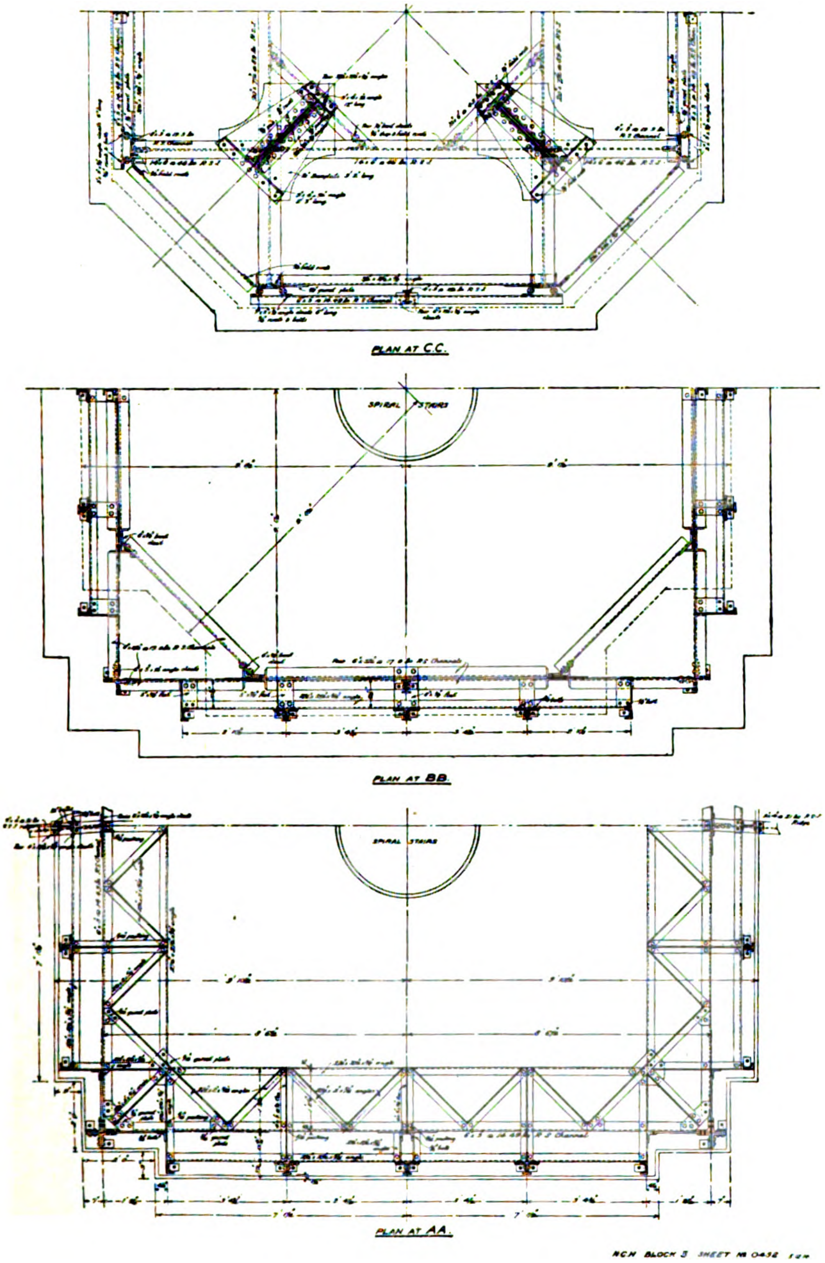

Fig. 3. Flèche—Plans.
THE NEW COUNTY HALL.

The two stancheons carrying the front legs of the flêche below the fourth floor are fairly typical of the stancheons generally, and one of them carries about 430 tons and is calculated according to the L.C.C. formula given in the Regulations for steel-framed buildings. It is composed of two 16 in. by 6 in. by 62 lb. rolled steel joists with two 16 in. by ⅝ in. and four 16 in. by ½ in. flats riveted to the flanges. The gross area is 88·5 sq. in., the least radius of gyration 4·53 in., and the pressure per sq. in. on the gross area 4·86 tons.

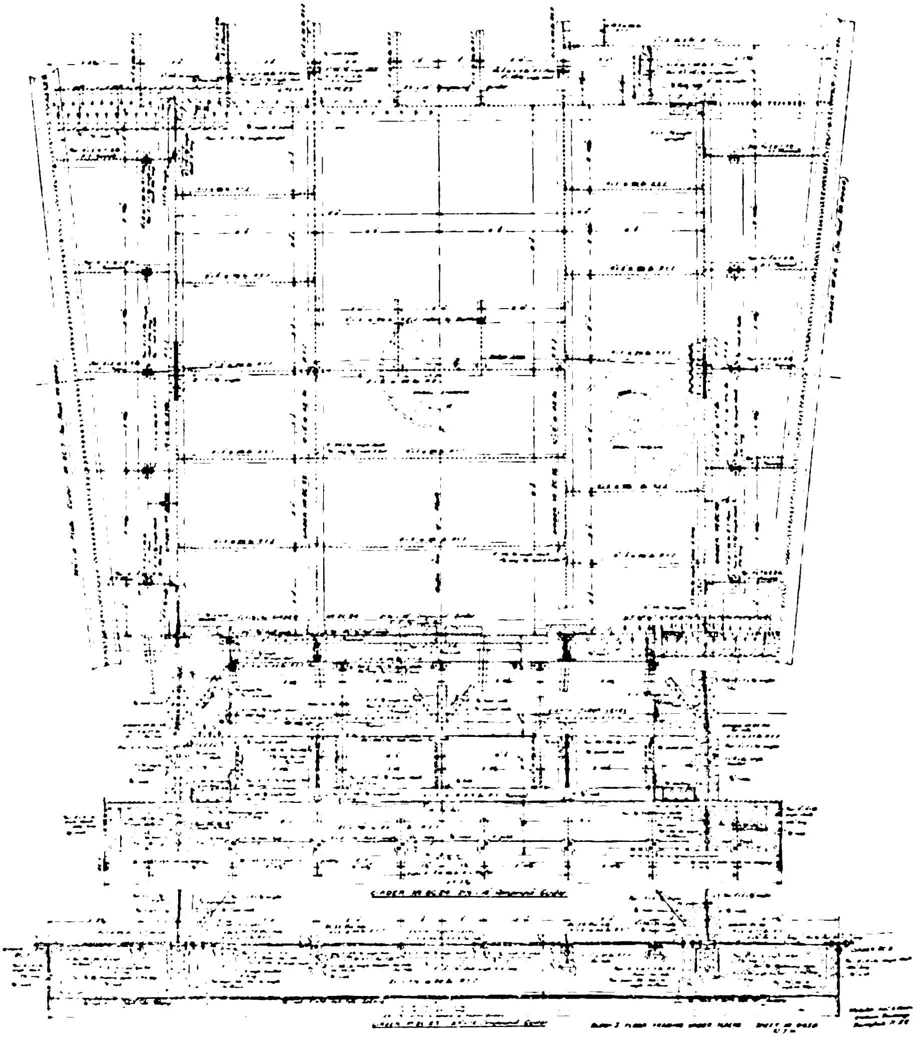

**Fig. 4** Plan of Framing at Base of Flêche.
The New County Hall

The base of the stancheon with gusset plates and stiffeners was machined square before the base plate was riveted on, and the top of the stancheon was treated in the same manner.

A grillage of two tiers of rolled steel joists distributed the load on the raft, so as to give a bearing pressure on the concrete of 12 tons per sq. ft.

The stancheons were erected in the following manner, that is to say, the grillages with their component joists spaced and bolted, and the two tiers bolted together, were placed in position on steel wedges and the stancheons were erected and bolted to them steel to steel. The stancheons were then plumbed and their tops brought to the right level, and the grillages then grouted underneath with neat cement, and finally filled in and around with fine Portland cement concrete.

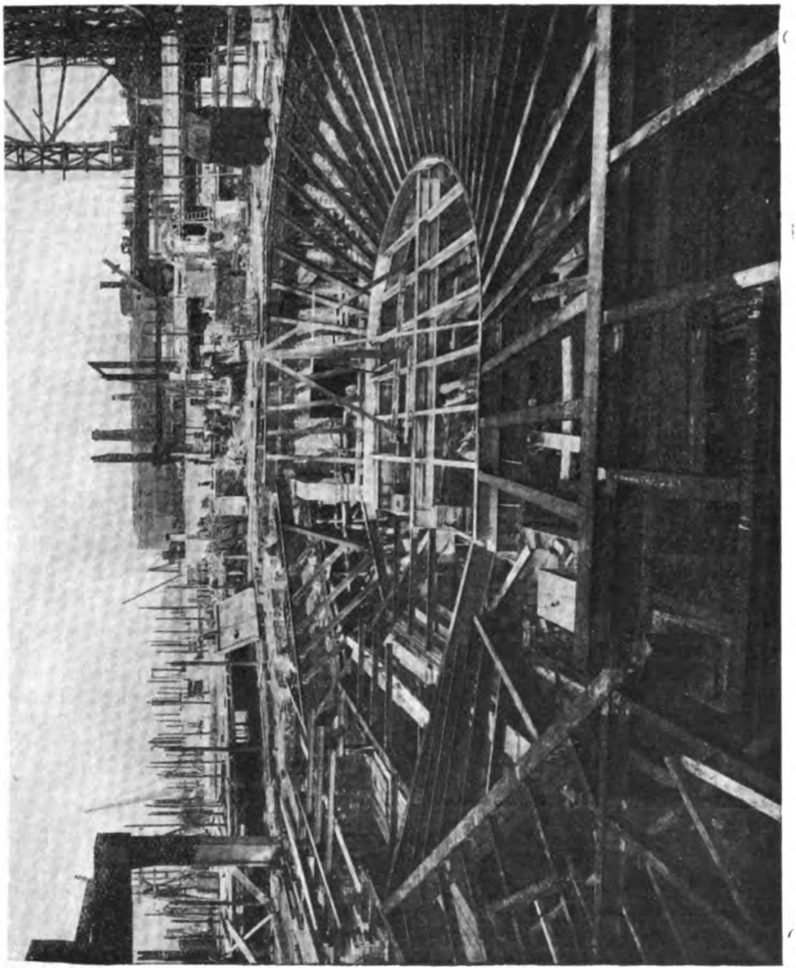

Fig. 5 The Floor of the Council Chamber.

The stancheons themselves, wherever they are of hollow section, are also filled with concrete.

The foundations and retaining walls are of interest :—

The top of the London clay was found to be generally about 32 ft. below the surface of the ground overlaid with 13 ft. of ballast, 7 ft. of Thames mud (in which the famous ancient barge was found embedded) and 12 ft. of made ground.

The concrete raft was placed on the top of the layer of ballast, being composed of five layers, each 12 in. thick, of six to one Portland cement concrete, not reinforced, a two to one Portland cement and sand damp course being laid between the first and second layers.

The retaining walls are also of mass concrete, six to one, about 23 ft. high, 10 ft. thick at the base, tapering to 4 ft. thick at the top.

There are six stancheons in the centre of Block 3, carrying the two rear legs of the flêche.

Some rather curiously shaped girders and an intricate interlacing of steelwork are to be found in the roof of one of the pavilions of Block 3.

The Committee Rooms on the first floor of Block 2 are two storeys in height, and the main front wall is carried on girders over these rooms. The partitions dividing the series into separate apartments are removable by sliding down between the walls on the floor below. Block 2 has a flat roof, as have also Blocks 5 and 12.

The upper part of the roof generally, which is an " A " frame of 10 in joists, tied at the middle height with pairs of angles, supports steel joist ridge and purlins, which in turn carry the 4 in. by 3 in. joist rafters. A system of diagonal bracing formed of 2½ in. angles, crossed, stiffens the roof at the collar level.

The roof slopes are to be of concrete 7 in. in thickness covered with red tiles of Italian pattern.

Reinforced concrete hardly finds a place in the building, but has been found convenient in some duct work, and especially in the walls and roof of a storey to be added over a part of Block 12.

### DISCUSSION.

**Mr. W. A. Green, M.A.,** asked what was the condition of the steel work after having been left exposed to the weather for so many months during the war when work on the building was stopped. Was anything done to protect the steelwork which was standing and how did it survive ?

**Mr. W. J. H. Leverton :** Towards the end of the paper the author stated that reinforced concrete hardly found a place in the building. Could the author give a reason for going in so thoroughly for steel and not using reinforced concrete. Another point was that the corridor walls were of sufficient thickness to carry the walls throughout. It was very common practice nowadays to make the corridor walls simply screens, and this facilitated alterations afterwards if necessity arose which was not possible when made in the manner indicated in the paper. Moreover, that form of construction was extravagant.

### THE LECTURER'S REPLY.

**Mr. Hall,** replying to Mr. Green's question as to the manner in which the steel withstood the weather during the time when work on the building was suspended, said that work proceeded for some time after the beginning of the war, but after that all the steel that could not be built in and concreted was treated with repeated coats of cement wash, and it was not in such a terrible state when operations were again begun. As to Mr. Leverton's question as to why the corridor walls were made so strong and not light, movable partitions, that was a question which could best be answered by the engineers. The architects gave them the plans and the steel was fitted to them.

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## MEMORANDA.

**Reinforced Concrete and the L.C.C. Regulations.**—A committee of the Concrete Institute are considering the amendment of the L.C.C. regulations for reinforced concrete buildings. In order that the County Council may be called upon to consider the amendments, the proposals of the Concrete Institute must be supported or supplemented by similar proposals by the Institution of Civil Engineers and the Royal Institute of British Architects.

**The Concrete Institute.**—On May 27th Major Halsted Best, R.E., F.I.S.E., etc., will read a paper on the Mystery Port, Richborough. There will be lantern slides. The following have been invited to take part in the discussion : Messrs. H. J. Deane, J. S. E. De Vesian, W. Pollock, F. E. Wentworth-Sheilds, Lieut.-Colonel J. Kerr Robertson, and others.

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER II.

23. *Compression Members and Columns.*—From what has already been explained it is clear that a column would in many cases be quite satisfactory as a compression member if simply constructed of plain concrete without any reinforcement, since concrete is strong in compression, and in certain cases it is justifiable in practice to build columns of plain concrete in this way. The writer constructed a factory to be used as a joiner's shop in which the central row of columns were 18 in. square without any reinforcement and carried three storeys. Where it can be ensured that the load will be absolutely central on the columns a safe stress of 600 lb. per sq. in. may be allowed, so that a column 12 in. square would have a safe load of $144 \times 600 = 86,400$ lb. $= 38\frac{1}{2}$ tons.

In most cases, however, it is by no means certain that the load will be quite central on the column, and that there will be no bending stresses set up, and therefore in practice a lesser load than this should be allowed as a safe value. This will be referred to later.

24. The objects of putting reinforcing bars in columns are principally as follows :

(*a*) As will be seen from *Fig.* 3, a reinforced concrete beam, when it deflects, necessarily bends, and when it is constructed continuously (*i.e.*, is monolithic) the reinforced concrete joint at the end will be a stiff one, and therefore deflection of the beam will necessarily produce bending in the column. The diagram in *Fig.* 3 is, of course, grossly exaggerated to make the point clear, and in practice the bending of both column and beam under loading is so slight as not to be visible to the naked eye though both are susceptible to measurement by a delicate instrument. It is, however, quite a mistake to assume that bending does not occur merely because it cannot be seen, and it must be remembered that shortening of the column due to the direct stress is also so slight that it cannot be seen with the naked eye, yet no one would venture to suggest in consequence that the column is not subjected to direct stress.

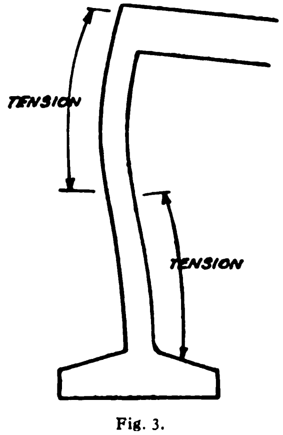
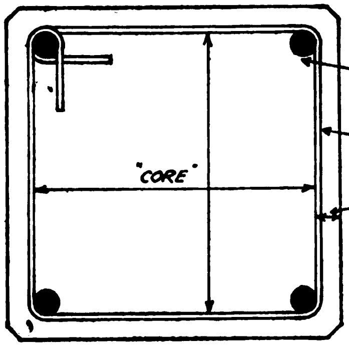
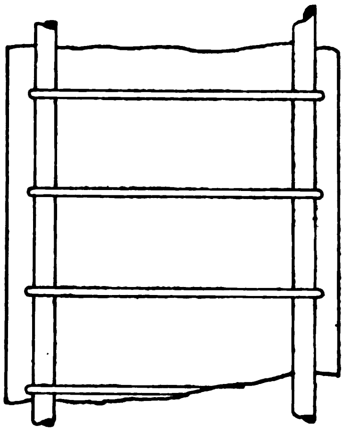


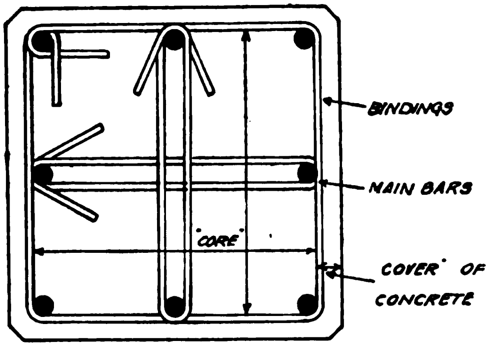
Fig. 3.
DIAGRAM SHOWING COLUMN BENT BY DEFLECTION OF BEAM (EXAGGERATED).

*Fig.* 3 referred to shows that the column, instead of being compressed, may be stressed in tension on one face for the upper portion and on the opposite face for the lower portion, and it is clear that when part of the column is in tension the total compression which it can safely carry is very considerably reduced. Nevertheless, the column is made much safer if vertical reinforcing bars are put in capable of resisting all tension of this

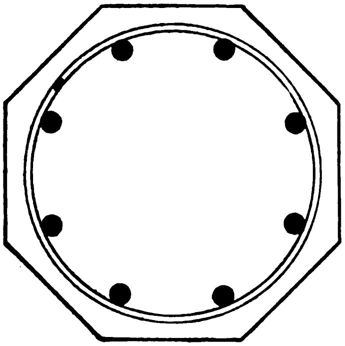


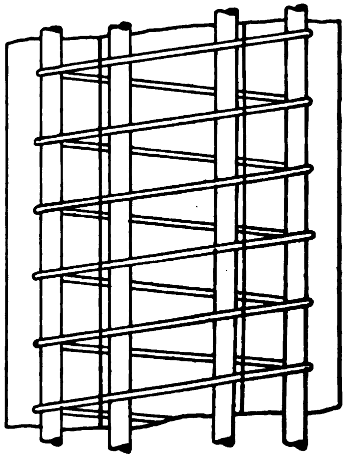


(*a*) Column with 4 bars.



(*b*) Column with 8 bars.





(c) Column with spiral bindings.

Fig. 2.
TYPES OF CONCRETE COLUMNS.

kind, since if a similar column were stressed in the same way without reinforcement it would simply crack across the tension plane.

(*b*) It will be remembered that the concrete in the column is constructed about 4 ft. high at a time, and then allowed to set before the next height is concreted. The planes between these two heights obviously have very little connection between them unless vertical bars are provided in the columns.

(*c*) When the columns are long in relation to their diameter there is a tendency for the column to buckle under loads. This buckling tends to produce tension on one face, and if reinforcement is provided this tension may be resisted quite safely, and the tendency to buckle be obviated; whereas, if no steel were provided on this tension face the tendency to buckle would not be resisted, and failure would occur.

(*d*) Where there is the slightest risk of unequal settlement, unequal expansion and contraction, etc., it is always possible that under certain conditions a few columns in a large complicated structure might actually be under tension when the surrounding floors were unloaded above and heavily loaded below. This would, of course, cause cracking across the columns, which would be entirely prevented by vertical reinforcing bars.

(*e*) Where the size of the column to carry the necessary load becomes excessive it can be materially reduced by adding a sufficient amount of steel reinforcement, since, as was explained in Paragraph 12, the stress in the steel will be fifteen times as great as that in the concrete, and therefore for each square inch of reinforcement we have the same load-carrying capacity as we should have in fifteen square inches of concrete.

25. For these reasons columns are generally reinforced with vertical bars. *Fig.* 2 shows the usual arrangements. That in Diagram (*a*) is the commonest form of reinforced column up to 16 in. square or thereabouts. After that eight rods are generally used up to about 24 in. square.

It will be noticed that the rods are placed near the edges of the column rather than towards the centre. The reason for this is that, as will have been noticed from the last paragraph, the object of the rods is principally to take up any tension which may occur during bending and, as such tension exists only near the edges of the column, it is here that the rods are most used.

It should also be noticed that as the rods are placed near the edge and are in general very long in comparison to their diameter they would be extremely liable to buckle, bursting the small cover of concrete away from the column and allowing the rods to buckle outwards and so destroy the column. To prevent this they are held in by means of bindings, clearly shown in *Fig.* 2. These bindings are generally about ¼ in. diameter, and occur at about 6 in. centres in the column, and vertical bars generally vary from ½ in. diameter up to 1¼ in. diameter.

Where four bars only are used square bindings are all that is necessary, but where eight bars are used square binding would not be effective in preventing the bars halfway along the face from bursting outwards, since considerable movement could take place before the binding became effective. Therefore additional bindings have to be used, as indicated.

Another form of reinforcement for columns is the spiral binding indicated in *Fig.* 2 (*c*). This was first thoroughly investigated by M. Considère. Spiral binding considerably strengthens the concrete by preventing it from bulging when the load is applied, but it has been shown that though the ultimate load on the column is considerably increased in certain cases when the amount of spiral binding used is considerable, it has little effect at ordinary working stresses, and for this and many other reasons spiral binding is not now so frequently used.

26. When calculating columns to be used in the open for bridges, viaducts, coal hoppers, etc., the whole area of the concrete may be reckoned on in calculating the safe load, but where columns are used in buildings it is sometimes considered advisable to allow the outside 1½ in. (called the "cover") of concrete simply as a fire-proofing, and to reckon that this cover in the case of a serious fire might be destroyed. It is clear that flames against the columns would heat up the outside and cause it to expand, and then possibly it might be drenched with water from the fireman's hose and be suddenly cooled, and it is quite likely that the "cover" might be stripped off the column. In many buildings it is

reasonable to insist that the columns should be strong enough to carry the load, even if the cover were destroyed in this manner, and therefore some regulations, including those of the L.C.C., insist that only the concrete inside the "hooped core" (*i.e.*, the concrete inside the area bounded by the outer surfaces of the vertical bars) shall be taken into account in calculating the strength of the column and the "cover" ignored except simply as a provision for fireproofing.

As regards the amount of reinforcement necessary, the L.C.C. require not less than 1 per cent. of the area of the hooped core shall be steel rods.

27. The calculations for the safe load on a column may be made very simply, as follows:

Let us take the case of a 12-in. square column and allow 1½ each cover. The area of the core is therefore 9 in. square, or 81 sq. in. If this column contains four ¾ in. diameter bars their area is 1·76 sq. in. As previously explained, each square inch of steel carries as much load as fifteen square inches of concrete, but, of course, it displaces 1 sq. in. of concrete, and therefore the net gain is only 14 sq. in. We therefore multiply the area of the steel by 14, which gives us 24·8 sq. in. of concrete, equivalent to 1·76 sq. in. of steel, and, adding this to the 81 sq. in. of concrete, we get the equivalent area of steel and concrete combined as 105·8 sq. in. This we may stress to 600 lb. per sq. in., giving us 63,600 lb., or 28·5 tons.

As explained before, this is only the safe load on the column when it can be guaranteed that the load will be absolutely central, and that no bending will occur; but these assumptions can very seldom be made, and this will be dealt with later.

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## MEMORANDUM.

**Cost of Underground Tanks.**—Mr. H. F. Boughton, writing in the *Gas World*, states that it may be of value to know generally, under present conditions, to what extent concrete is cheaper than brickwork for underground tanks and pits. Take, as an example, an underground tank 24 ft. by 12 ft. by 6 ft. deep, inside measurements, having sides, ends and bottom of 9 in. concrete. This will mean an excavation of 25 ft. 6 in. by 13 ft. 6 in. by 6 ft. 9 in. deep. If the ground is fairly solid it will safely hold up at this depth without being waled and strutted. In brickwork of similar size, and with 9 in. work, the excavation will need to be somewhat larger owing to footings and plumbing, but this need not be taken into account in comparing the difference of cost, as it would not be much; therefore the cost of walls and bottom only will be compared.

Take the concrete tank first: there will be 600 c. ft. of concrete, and if of 6 : 2 : 1, with 5 per cent. of Pudlo per volume of cement, it will work out at 1s. per cube ft. *in situ*—£30. If the shuttering is made of old timber, in a correct manner, it will be easily removable after the concrete is set; and, of course, it is only required for the sides and ends. The first cost of this timber should not be reckoned, as it can be removed and used for other purposes. Under these conditions the most the shuttering should cost in making, fixing and removing should be £20, so that the total cost of such a concrete tank will be £50, exclusive of the cost of excavations.

Now take the tank built in brickwork: there will be 700 cu. ft. 9 in. work, owing to the footings, and, without including the necessary layer of concrete for the base, the brickwork alone equals 2·28 rods, which will cost £35 per rod—£80. If the tank in brick is to be made waterproof it must be rendered with Pudloed cement mortar, or other waterproofing means applied. This, together with the concrete foundation, or base, will run the cost of the brick tank up to £100. When it is considered that there are 12,500 bricks in the walls and bottom of the tank, which may probably now cost £4 per thousand—£50—it would be fairly correct to say that, in all ordinary cases, a concrete underground tank or pit can be constructed at one-half the cost of a similar size one in brick.

# THE FOREIGN PRESS.

*The following are abstracts taken from the foreign Press relating to concrete construction.—ED.*

**What is Portland Cement?**—According to a writer in *La Revue des Materiaux de Construction*, the ordinary definitions of cement give no idea as to its actual nature, and when we turn to the various investigations which have been made upon the subject it is still almost impossible to get a satisfactory answer to the question—" What is Portland cement and of what does it really consist ? "

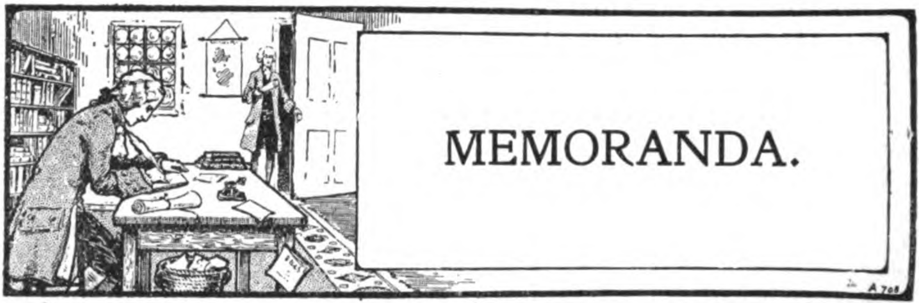
Scientists who have studied the subject appear to be divided into two groups, one of which declares that Portland cement is merely impure tricalcium silicate, whilst the other group maintains that it is a highly complex mixture of various silicates and aluminates. Those who regard it as an impure silicate have clearly overlooked the very considerable proportion of alumina which is always present, and yet to include this would at once destroy their theory. Those who regard cement as a complex mixture have derived their idea chiefly from a study of the behaviour on cooling of a number of pure oxides which have previously been heated to complete fusion, whereas Portland cement never reaches this stage, but is only heated to the sintering point. It is also a curious fact that when Portland cement of excellent quality is fused completely in an electric furnace, and is then allowed to cool slowly, it does not possess the special characteristics of cement clinker, but behaves as an entirely different material.

The fact is, there has been far too much guess-work and mere theorising where there should have been a broad-minded examination of the whole of the known facts. For instance, it has not been definitely determined how far the constitutents which first melt during the burning of the cement attack those which are more refractory, and it is assumed, rather than proved, that such attack and fusion proceed progressively. If the most fusible materials melt first, there ought to be visible under the microscope particles of fused material uniformly throughout the mass, whereas a microscopical examination of the smallest particles shows that they are only fused superficially. This superficial fusion may not be due to the presence of more readily fusible particles at all ; it may be caused by the low thermal conductivity of the material which allows the exterior of a particle to fuse but does not permit the heat to penetrate into the interior sufficiently to raise the whole particle to fusion point. In fact, the phenomenon of fusion, which appears so simple to the uninitiated, is, in reality, so complex as to be almost impossible of exact observation when studied in connection with such substances as cement and clays. In metallurgy, the microscopical examination of polished and etched specimens often enables the crystalline structure of the metal to be recognised and its various constituents to be identified, but this method fails in the case of Portland cement because it demands a complete fusion of the mass—which does not occur—and the production of normal or nearly normal crystals, whereas in clinker the presence of the impurities and the absence of sufficient fusion prevents the proper formation of a crystalline structure and makes the identification of alite, belite, etc., wholly inconclusive, though these substances are recognisable in completely melted mixture of pure oxides with a composition resembling that of the cement.

Attempts at synthesis by means of pure materials have not led to any conclusive results, as such synthetic mixtures are always " poor " cements, the impurities present in the natural materials playing a far more important part in giving the cement its valuable properties than is commonly supposed. The addition of water to cement provides additional complications without removing any of the other difficulties experienced in endeavouring to ascertain its constitution, for water decomposes the cement, liberating free lime which reacts with the other constituents and sets up a fresh series of reactions. The substitution of other fluids has not, so far, led to any striking results.

It is easy to suppose, with a German contemporary, that cement consists of a single chemical compound, but no one has yet proved whether this substance exists.

Another impossible explanation is worth consideration : if the formation of cement is due to the presence of a catalyst which is included among the impurities, it ought to be possible either to isolate this or to substitute another catalyst for it and so facilitate the production of the cement and make the determination of its constitution much easier. The discovery of such a catalyst might make the production of a pure cement possible.



# MEMORANDA.

*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Salvaging Steel Reinforcement.**—An interesting experiment has been carried out in Canada in reclaiming reinforcing steel from a concrete bridge which was destroyed by flood and utilising it again in the construction of a new bridge. The old concrete was broken up by sledge-hammers and dynamite, and over 100,000 lb. of steel was salved. In the course of the work it was noted that the hammers were generally more effective than the dynamite in breaking up the concrete. The steel was twisted and bent by the collapse of the bridge, but after being straightened out it was found to be undamaged and fit for re-use. The cost of salving the steel worked out at about 1¼ cents per lb.

**Reinforced Concrete in South America.**—We learn from our correspondents Messrs. Hume Bros., of Buenos Aires, that a great deal of interesting reinforced concrete work is being done in South America. They send us photographs of some recent works carried out by them, which we reproduce together with some brief particulars. *Fig.* 1 shows some concrete chimneys and 1,000 ton silos erected for a cement works in South America.

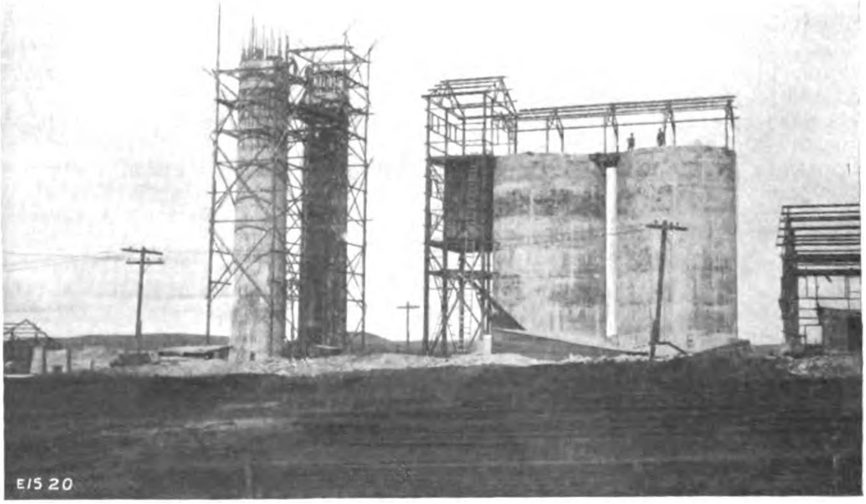


FIG. 1. 150 FT. CHIMNEY STACKS. SILOS FOR A SOUTH AMERICAN CEMENT PLANT.

*Fig.* 2 shows two new buildings erected in concrete for a refrigerating plant in Buenos Aires. The left-hand building is of steel frames resting on a reinforced concrete raft. The other building is a reinforced concrete frame resting on 600 concrete piles, and having brick curtain walls. Messrs Hume Bros. are at present constructing a reinforced concrete wharf over a mile in length. We hope to publish full particulars of this wharf later on.

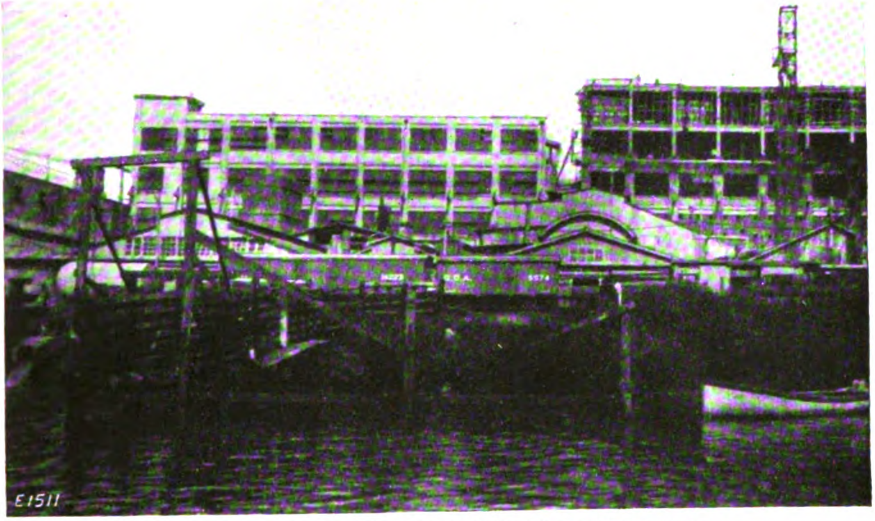
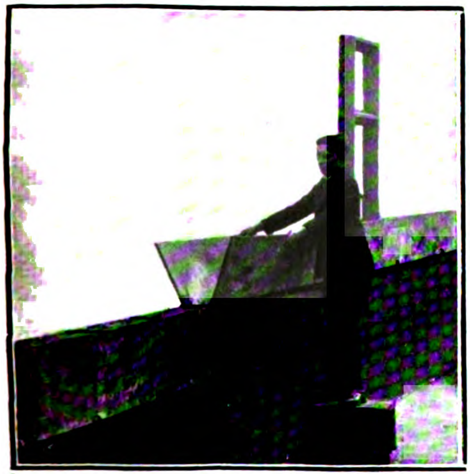


FIG. 2. BUILDINGS FOR A REFRIGERATING PLANT AT BUENOS AIRES.

**New Concrete Coal Handling Dock.**—The Pittsburgh Steel Company has secured permission from the Government for the construction of an 800-ft. concrete coal-handling dock at the company's plant at Monessen (Pa.), on the Monongahela River,

Shuttering Costs Reduced 90 Per Cent.



The only shuttering which does not require to be taken off and refixed; it merely folds up.

Timber and Carpentry practically eliminated.

On Exhibition at Olympia, Stand 77 E.

The CLIMBING STEEL SHUTTERING Co.
515 Queens Road, SHEFFIELD.

and will immediately construct its new fuel system which will enable it to handle all of its coal supplies by water, states the *Coal Trade Journal*. The new docks will be among the largest in the upper Monongahela pools.

**A Reinforced Concrete Factory in Scotland.**—In our frontispiece we show an illustration of a factory built in reinforced concrete on the Kahn system to the designs of the Trussed Concrete Steel Company, for the Albion Motor Car Company, Ltd., Glasgow. The building was completed during the war, and comprises workshops and stores. To secure firm foundation, as the site is near the river Clyde, the column foundations rest on a stratum of boulder clay from 6 ft. to 8 ft. below the ground level, and are estimated to withstand a pressure of 3 tons per sq. ft. The column bases vary from 4 ft. to 7½ ft., and special bases had also to be devised.

**New Fish Market at Grimsby.**—The first reinforced concrete pile for the reconstruction of Grimsby's fish market was recently laid. Each pile measures 60 ft. in length and weighs 7¼ tons. The actual work of rebuilding the market is expected to commence shortly.

### ERRATUM.

**Concrete Fence Posts.**—We regret that in reporting the discussion which followed the reading of Mr. Grimshaw's paper on Fence Posts there were one or two printer's errors :—

*Page* 283, *line* 12.—Posts 8 ft. out of ground and 4 ft. sq. at top should read " 4 in. at top."

*Line* 13.—Read " some tons," instead of many hundred tons.

*Line* 22.—The author had no difficulty about gate posts, they were most successful.

*Last line*.—Read " 10 ft., 12 ft., or 15 ft."

### RECENT PATENT APPLICATIONS.

No. 139,010.—T. Lant : Concrete block-making machines.

No. 139,294.—T. E. Hardy : Stanchions and beams for hollow wall buildings.

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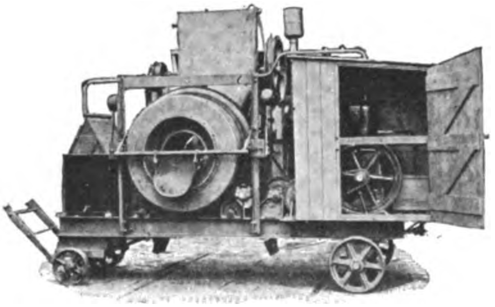

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*A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.*

ISSUED MONTHLY

## CONTENTS.

Editorials.

Concrete Cottage Building.

Calculation of Rigid Frames.
By V. ELMONT, B.Sc.

Reinforced Concrete Roads at the Portsmouth Gas Works.
By S. E. WHITEHEAD, B.Sc., Eng.

Notes on the Deterioration of Structures in Sea Water.
Report of the Institution of Civil Engineers.
By Prof. E. R. MATTHEWS, Assoc.M.Inst.C.E., etc.

New Developments in Surface-Treated Concrete and Stucco.
By T. C. PEARSON and J. L. EARLEY.

Concrete in Sewer Construction.

German Fire Tests on Reinforced Concrete Houses.
By Dr. ARTHUR HOLMES, D.Sc., A.R.C.S., F.G.S.

Recent Views on Concrete and Reinforced Concrete.
The Consistency of Portland Cement, Mortar and Concrete. By H. G. LLOYD, A.G.C.I.
The Manifold Uses of Concrete. By T. J. CLARK.

Concrete Shipbuilding.
By Alfred B. SEARLE.

Concrete in Theory and Practice.
Reinforced Concrete Simplified. By OSCAR FABER, O.B.E., D.Sc., etc.

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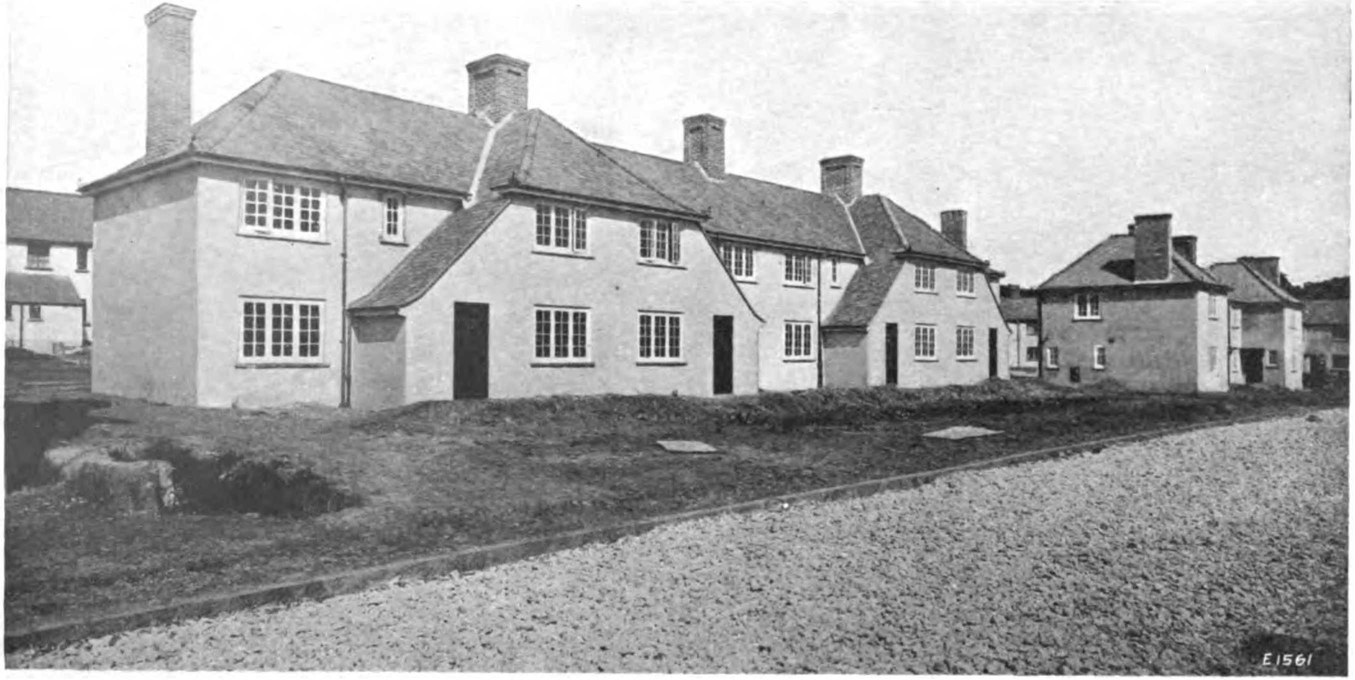

Some Houses at Chepstow, Bulwarks Village; The Cross Way.
(*For description see page* 371.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XV. No. 6. LONDON, JUNE, 1920.

# EDITORIAL NOTES.

## HOUSING BONDS.

It is admittedly difficult for those who stand in close proximity to a great movement to apprize its real significance, for such propinquity cannot but yield a distorted vision, and any attempt at appraisement must therefore be in the nature of a surmise, the final assessment remaining as a task for posterity. It behoves us, however, from time to time to make an effort of genuine detachment in order to appreciate the trend and direction of some particular movement and to discover what degree of success or failure it has so far achieved.

### NUMERICAL RESULTS A SUPERFICIAL TEST.

Considered numerically, it may, with some justification, be said that the results obtained through the medium of the Government Housing Acts are disappointing, tenders for only some 100,000 houses having been accepted, of which but a small proportion are so far in actual course of erection ; yet to see no deeper significance in the housing movement is to confess to a lamentably superficial estimate of the entire matter. Further consideration will show that the interest of the whole nation has been aroused in the subject of housing as never before, and to-day scarcely a parish exists in England that has not its committee of local men and women considering the question of housing in all its latest manifestations. The effects of such a development of national consciousness cannot fail to show itself eventually in manifold ways, amongst which may be cited an increased sense of civic pride, improved standards in housing and in living, a renewed popular appreciation in domestic architecture which must undoubtedly act for the good of the latter. These are results which are not immediately apparent, but are nevertheless extremely important, for their effects are far-reaching. To ignore them would be both short-sighted and unjust. Furthermore, it must be admitted that official sympathy towards new materials and methods of construction has been very great, and that but for the action of the Government in suspending effete bye-laws it might well have taken many years for concrete to attain to the position of importance which it now holds as a recognised material for house construction.

### FINANCIAL DIFFICULTIES.

Yet all these potential beneficial results will be indefinitely postponed, as will the erection of the very houses themselves, the need for which becomes ever greater with each unwelcome delay, if the money is not forthcoming with which to pay for them. During the war the response to constant appeals for an endless stream of money was both immediate and emphatic ; a similarly spontaneous response for a very much shorter period would provide all the money required for this great undertaking.

### GREATNESS OF THE PRESENT OPPORTUNITY.

It is probably still insufficiently realised how unique is the present opportunity for effecting social improvements on a comprehensive scale such as has never before been possible, for, from whatever aspect the problems of the day may be considered, housing is, as it were, the root of the question. Thus one person may see the future menaced by the present state of unrest in which we are, even in England to some extent, living. The Royal Commission on Industrial Unrest reported that bad housing conditions were a potent factor of social unrest. Another person may view with alarm the low birth rate ; the connection between this and inadequate housing is too patent to require comment. Again, reduced output appears to some as an alarming symptom ; yet bad housing conditions, with consequent discontent and restlessness, are responsible for much of this restricted output. During the war one of the most persistently reiterated phrases was " homes for heroes," and those who were serious in their use of it have now an opportunity of showing their good faith, showing it, moreover, at no loss to themselves, for 6 per cent. cannot be regarded, even to-day, as a poor investment.

Local response to the Housing Bonds campaign has varied very much in different districts ; thus some local authorities have already obtained all the money which they require for their full building programme, while others are experiencing the greatest difficulty in arousing even the most meagre local interest. This difference, however, cannot be taken as a measure of local pride or patriotism, for public interest is aroused, as was so effectually demonstrated during the war, by successful methods of poster propaganda, by well-chosen advertisements, and, above all, by the friendly tone of the local press, and while some authorities have displayed the greatest ingenuity in the methods which they have adopted to stimulate interest, others have shown but little enterprise.

At the end of July a year will have intervened since the first post-war Housing Act was placed on the statute book. By that time an immense amount of work will have been done by Government departments, by architects, by the officials of local authorities, and by voluntary committees, but the final effort must be made by the public, and the enormous import of the present opportunity—an opportunity such as may never occur again for each to make his contribution—should be realised by every grade of worker throughout the land.

### SAFETY FIRST.

A question of vast importance, and one which may have far-reaching consequences, has arisen with regard to the laying of sewers in London in connection with the development of housing schemes.

As will be seen from a report of the General Purposes Committee of the London County Council, which we reproduce in the present issue, the position is this : The Main Drainage Committee have received an application from the

Hammersmith Borough Council for the approval of the sewers in connection with one of the council's housing schemes ; but the plans, except in the case of one road, showed no concrete surrounding the sewers, the statement being made that the Ministry of Health would not permit the use of this material. The Committee refuse, and propose to refuse, to sanction sewer applications in which the employment of concrete is not specified.

In this we are entirely at one with the Committee. As is pointed out in the report, the immunity of the metropolis from devastating epidemics such as visited the city in bygone days is mainly due to improved sanitation, of which its system of drainage forms the most important feature, and any relaxation of regulations which provide such an efficient safeguard is to be deprecated, since it would, in our opinion, constitute a menace to the health and well-being of the community.

We can understand the anxiety of the Ministry of Health to expedite the erection of dwelling-houses with a minimum of expense, but, important as these considerations are, the health of this and future generations demands that the practice of sanitary engineering should be kept fully up to the standard which has hitherto been adopted. Sewers are not structures of to-day or of to-morrow only, but are laid with a view to a long period of service, and it is essential, therefore, that the soundest methods should be adopted, and every precaution taken in order to avoid the possibility of failure which would react upon the community, both financially and hygienically.

Upon examination of the views of the Ministry of Health on this subject as expressed in their letter to the London County Council, it will be seen that obviously extreme cases alone are provided for, as, for example, " Where the nature of the ground provides a bad foundation," or, " where the depth of cover above the pipe exceeds 14 ft., or is less than 4 ft. in roads, or 3 ft. in fields, or other places used by carts, etc." The curious thing is that " where the internal diameter of the pipe exceeds 15 in., it may be strengthened with concrete *where considered necessary*." (The italics are our own.)

One is tempted to ask who is to be the judge as to what is or what is not, for the purpose in view, a bad foundation, and whether what may at the time of laying be an apparently good foundation may not, under exceptional conditions prove to be defective, and in the case of the pipe which exceeds 15 in. in internal diameter, what are supposed to be the conditions necessary for the use of concrete, who is to decide upon them, and why those conditions should not apply to other and lesser sizes of pipes ?

It seems to us that in these regulations there is insufficient margin for the unexpected—that the factor of safety is ignored. It is as though one were to construct a beam or a floor and allow for the minimum load only. If this principle were to become general it would be disastrous. In the interests of safety, let us err, rather, on the side of generosity in the matter of safeguards than on that of inadequacy.

Our opinion is that these are matters which should be left entirely for the London County Council to decide at the recommendation of their Main Drainage Committee.

The crux of the matter appears to be a question of cost, since the expenditure incurred in the laying of sewers does not rank for State financial assistance, but inasmuch as drainage, equally with housing, is a question of national moment, we agree with the recommendation of the Committee that such expenditure should be partly borne by the State.

### SPECIAL METHODS OF COTTAGE CONSTRUCTION.

The Ministry of Health has selected eleven sites on which houses constructed by special methods will be available for inspection by representatives of local authorities and others interested in housing. Several firms have already agreed to erect houses on their special system and negotiations are proceeding with other firms. It goes without saying that the bulk of these houses will be of concrete, and an excellent opportunity will be afforded of comparing their external appearances. But concrete cottage construction may be roughly divided into two classes—monolithic and block construction—and within these two classes the only variations are those of architectural design ; also, the plans of working-class houses are now practically standardised. The elevations and planning, therefore, will not be of very great assistance to those wishing to decide for themselves which are the best *methods of construction.* The relative merits of the numerous systems lie in the actual construction, and we think the value of the exhibitions would be much enhanced if small sections of walling—preferably actual size—were available for inspection, not necessarily in juxtaposition to the houses to which they relate, but, perhaps, collected together on a corner of the site.

# CONCRETE COTTAGE BUILDING.

## BULWARKS AND PENNSYLVANIA VILLAGES, CHEPSTOW.

"WHATEVER may be the fate of the National Shipyards," said the *Times* in an article on Chepstow, "the Government will be able to point with pride to the garden cities they are erecting"—garden cities, it might have added, whose houses are constructed in concrete, a procedure that might have evoked an anathema a few years before the war from the more conservative of those whose interests are concerned with building.

The first housing scheme at Chepstow, in connection with the yards of Messrs. Finch, has already been described in these columns. It will be remembered that this scheme was at Hardwick village, and the architects were Messrs. Dunn, Watson and Curtis Green. The village at Bulwarks is somewhat to the south of Hardwick, to which it is connected by paths through the Hardwick Woods. The site is perfectly situated among some of the most beautiful country in England, and the village is planned on a southerly slope overlooking the Wye and the Severn.

The town is designed for 1,150 houses. The shopping centre is situated along Thornwell Road (see *Fig.* 1), and in planning the disposition of these buildings a feature has been made of a fine old oak tree, protected by a raised bank which covers its roots, and which is ascended by a flight of steps. From this eminence a view is obtained down The Avenue to the woods beyond (see *Fig.* 2). Branch roads lead off from The Avenue, which approximately adhere to the contour lines. On the first of these roads, appropriately called Alpha Road, the first houses, some of which are shown in *Fig.* 3, were built, and fifty of them were completed and occupied within three months of the commencement of the layout. Alpha Road leads to the Roman camp, which is now pleasantly covered with fine old trees. The next road is known as Beta Road, and on it B-type houses are built.

At the end of The Avenue a circular space is planned with a bandstand as central feature, surrounded by seats. The positions of the schools and churches have been carefully considered. The schools are liberally surrounded by open spaces, and the vista of Church Walk is closed by the Church of England, with the vicarage behind situated in a large piece of ground falling toward the woods beyond.

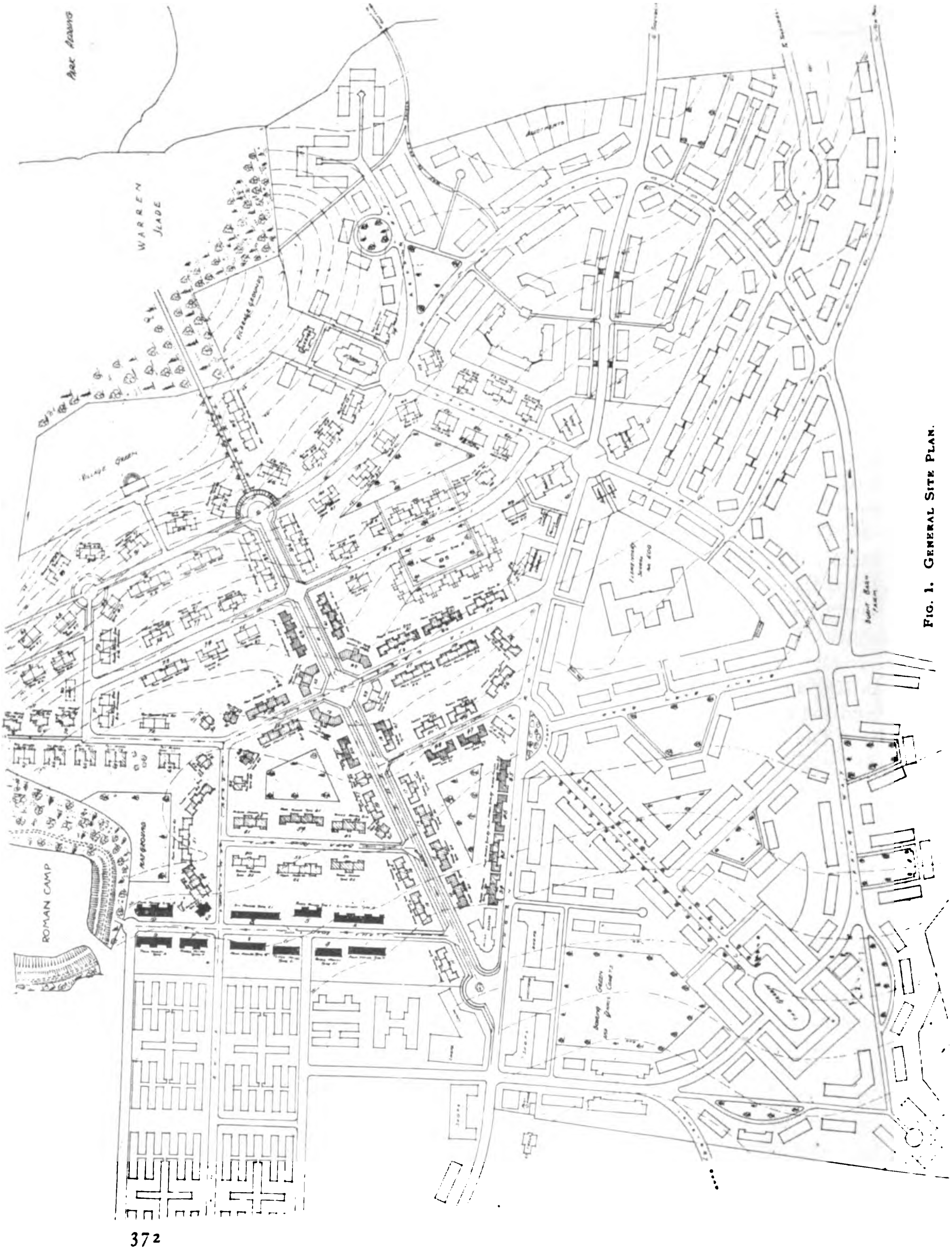

Fig. 1. General Site Plan.

In addition to the two villages of which mention has been made—Hardwick and Bulwarks—the scheme includes Buttington village, which is to be composed principally of A-type houses, and Pennsylvania and Sedbury villages, in which a considerable amount of building has been completed. Both these villages are situated on the east bank of the river Wye. *Fig.* 5 shows a group of four houses nearing completion in Pennsylvania village, and *Fig.* 6 shows the plans and elevations of some houses and flats grouped round a quadrangle, whose planning would repay careful study, in the same village.

Enough has been said to give some idea of the vast magnitude of the scheme, which, it must be remembered, was undertaken during the war and under the particularly unfavourable conditions with which all are familiar. The impossibility of obtaining bricks in anything approaching adequate quantities was at once apparent, and so it was decided to employ a similar method of construction to that which was proving so successful at Hardwick—viz., concrete blocks, manufactured on Winget machines.

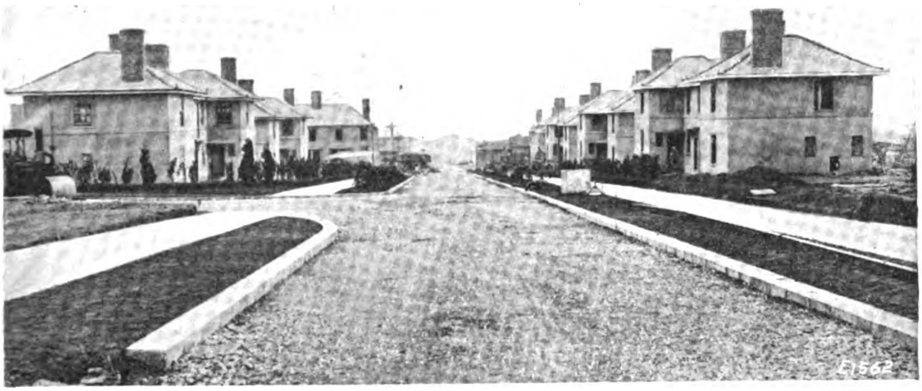

FIG. 2. THE AVENUE, BULWARKS VILLAGE, CHEPSTOW.

The method of semi-dry mixing employed with this machine is too well known to require a detailed description. The construction is that of the straightforward cavity wall type with iron ties, the inner leaf having a proportion of breeze to avoid condensation. The continuous cavity successfully excludes the heavy driving rains of the West of England. The interior wall surface requires only two coats of plaster-work; in fact, in some instances only a skimming coat is employed. As far as possible the work was designed in order to avoid cutting and the manufacture of many special blocks; the doors and windows were standardised for the same object. It is inevitable that a certain number of special blocks must be made for chimneys, sills, door hoods and the like, and particular care was devoted to the design of these parts.

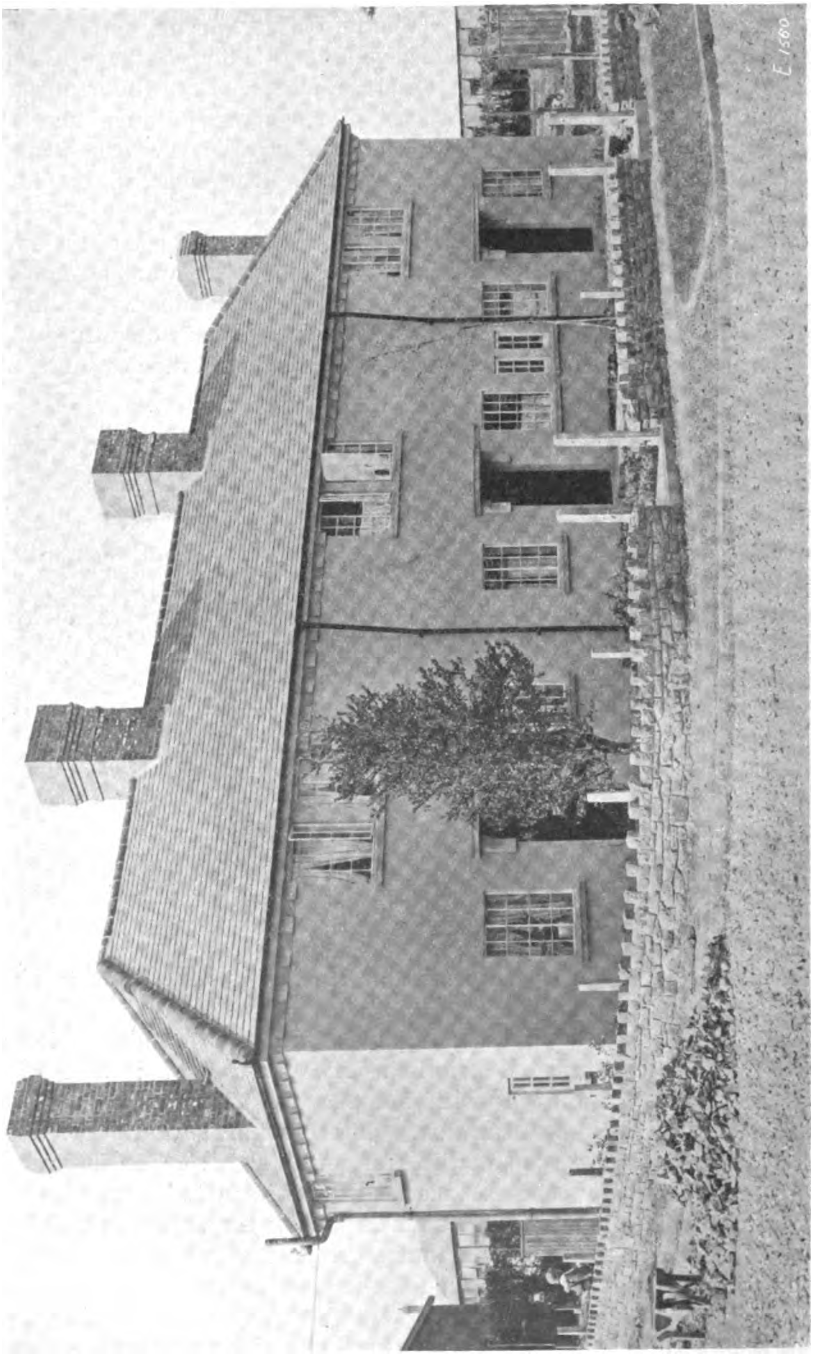

Fig. 3. Type "A.1" Houses, Alpha Road, Bulwarks Village, Chepstow.

A plan of one of the many types of pairs of houses is shown in *Fig.* 7. It will be noticed that one of the houses contains five bedrooms; the extra rooms have been skilfully planned in order not to interfere with the symmetry of the elevation. Another interesting point is the grouping of all the flues of each house into a single stack. A half-inch detail of the same house is illustrated in *Fig.* 8.

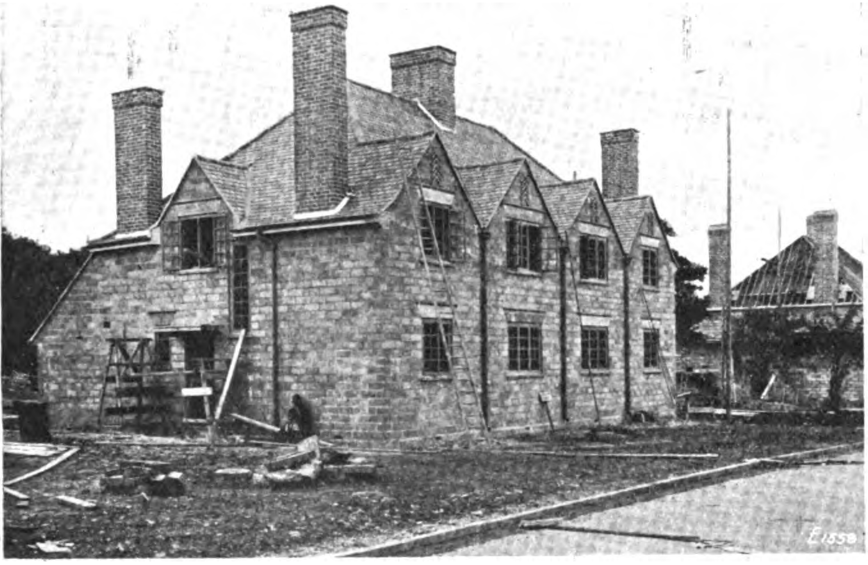

FIG. 4. TYPE "C.1" HOUSE, BULWARKS VILLAGE, CHEPSTOW.

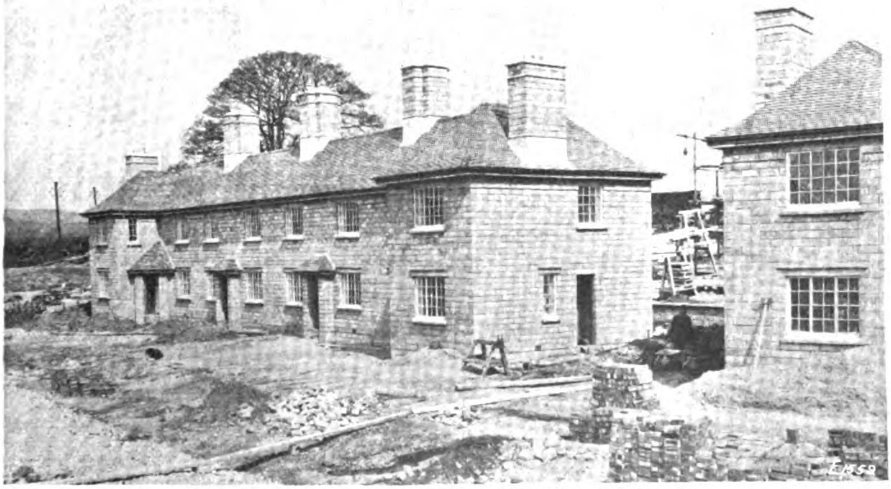

FIG. 5. TYPE "B.2" HOUSES, PENNSYLVANIA VILLAGE, CHEPSTOW.

It is possible, owing to limitations of space, to select for reproduction only a few of the many types of houses, and these fail to convey an adequate idea of

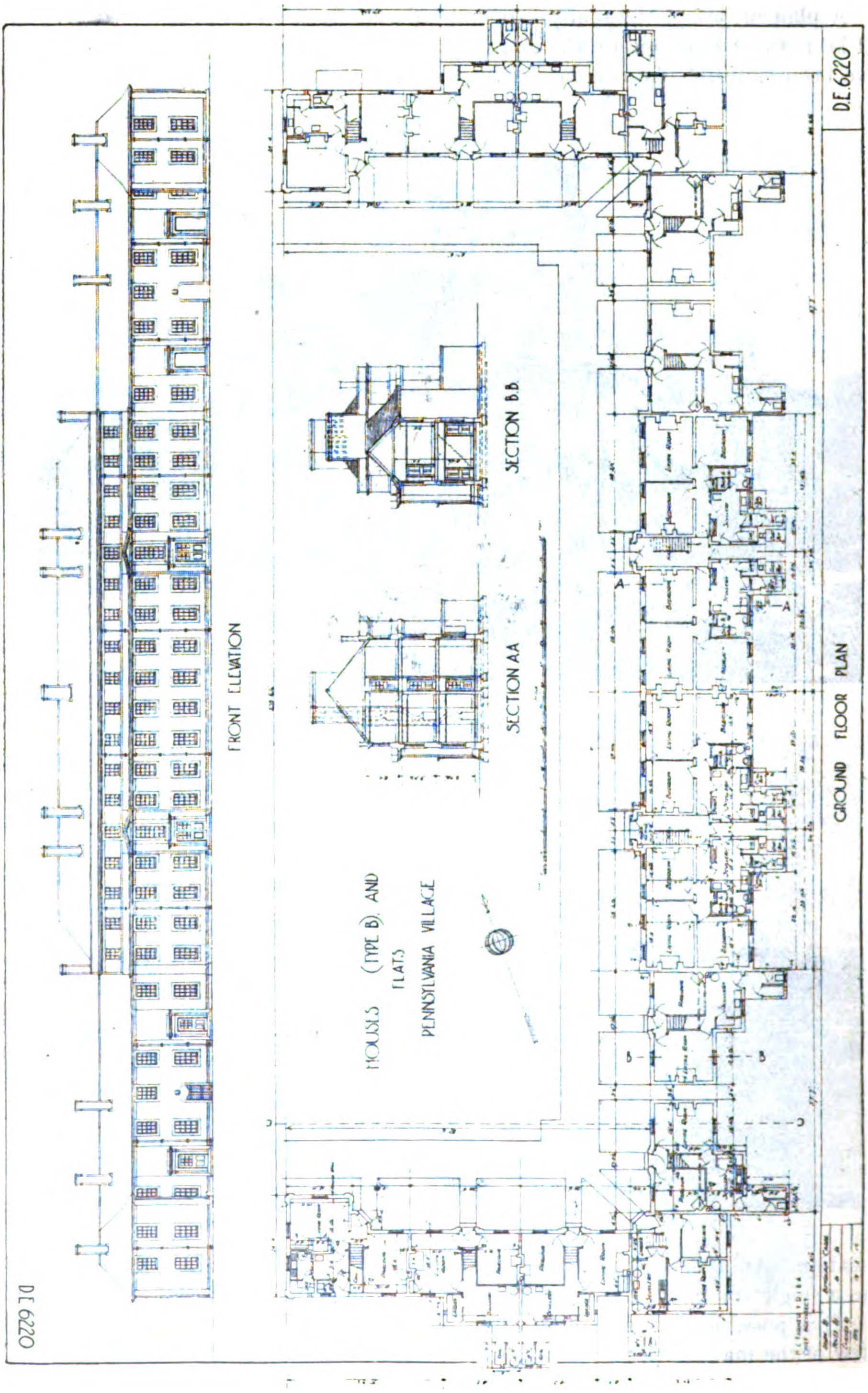

Fig. 6. Plans and Elevations, Pennsylvania Village, Chepstow.

the vastness of the scheme, but they should serve to indicate the enormous variety of treatment that not only concrete as a material, but concrete blocks of a particular kind, are capable of yielding to the thoroughly skilful designer. It is only necessary to compare the charmingly simple A-type group of *Fig.* 3 with its unbroken roof, its smooth expanse of rendered wall surface, the long cornice made interesting by the dentil course, the beautifully proportioned windows

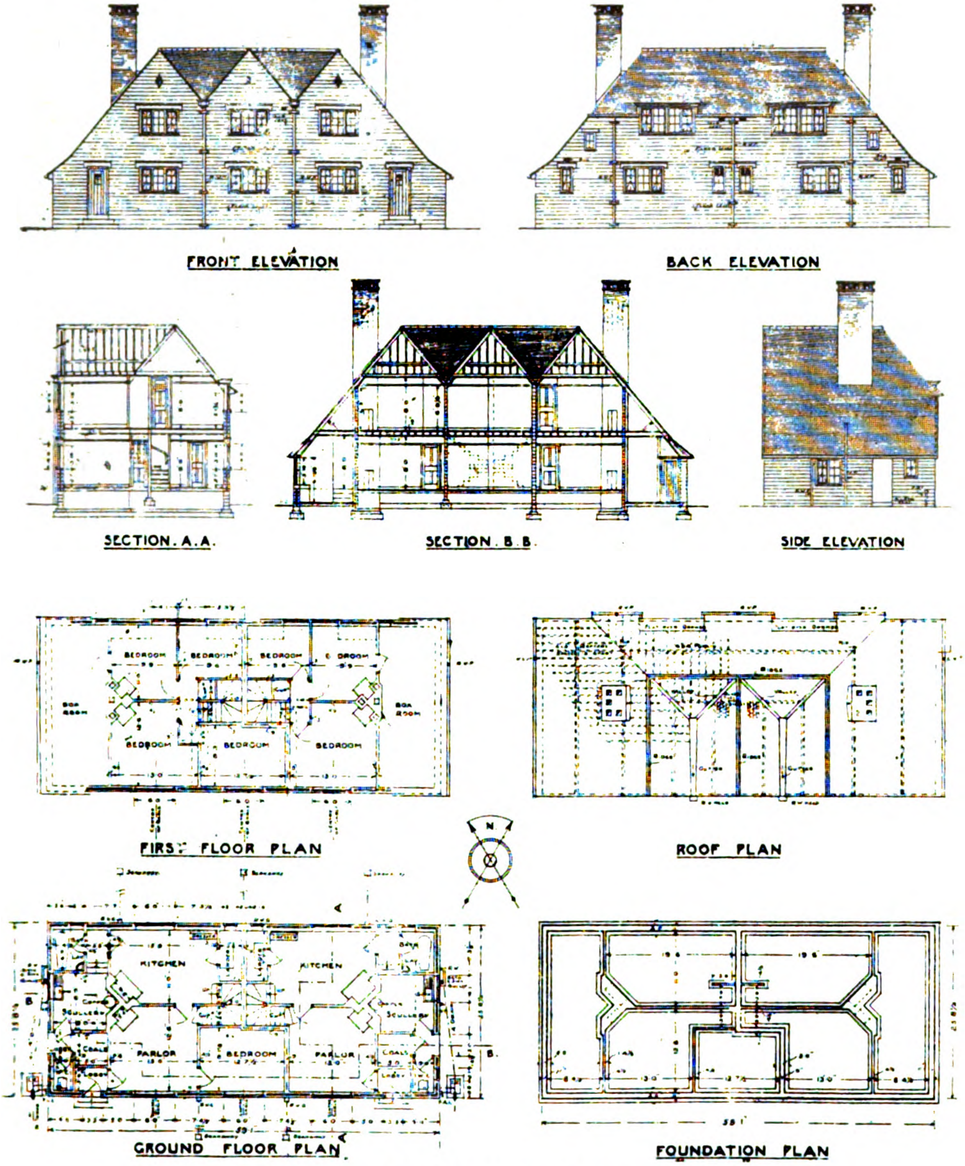

Fig. 7. Type "B" Houses, Chepstow.

and the modest hood over the door, with the block of B houses illustrated in *Fig.* 5, which is treated none the less excellently, but entirely differently The wall surface is broken up by the blocks which are not covered externally, and

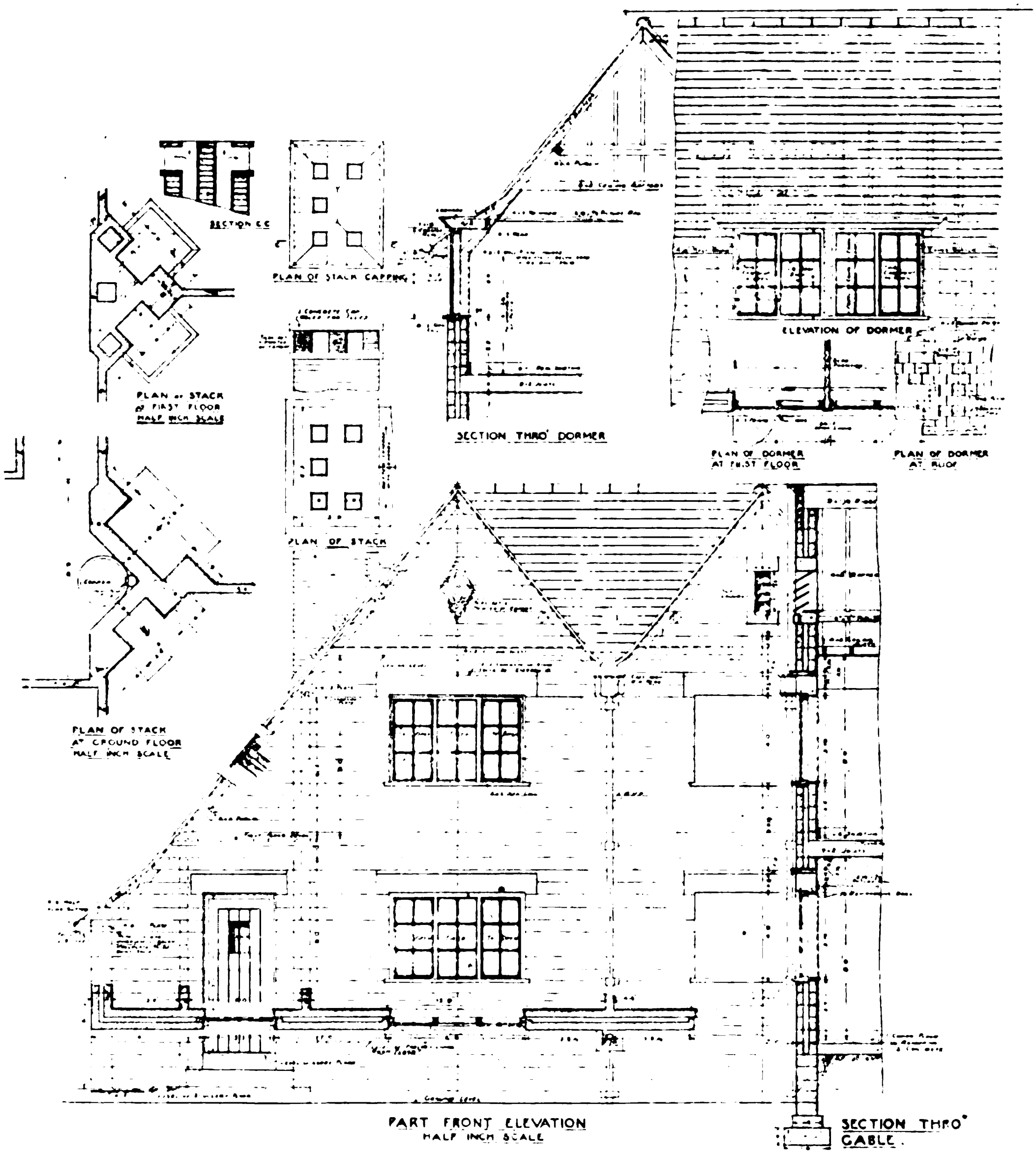
SECTION C.C
PLAN OF STACK CAPPING
PLAN OF STACK AT FIRST FLOOR HALF INCH SCALE
PLAN OF STACK
SECTION THRO' DORMER
ELEVATION OF DORMER
PLAN OF DORMER AT FIRST FLOOR
PLAN OF DORMER AT ROOF
PLAN OF STACK AT GROUND FLOOR HALF INCH SCALE
PART FRONT ELEVATION HALF INCH SCALE
SECTION THRO' GABLE.

FIG. 8. HALF-INCH DETAIL, HOUSES AT CHEPSTOW.

in many cases the joints are finished with a pleasantly tinted yellow mortar. The treatment of the porches, the chimney stacks, the window lintels, is also entirely different. Again, in the examples shown in the frontispiece the effect is more rural, the long low sweep of the verges over the doors and the brick stacks imparting a changed character to the house. In *Fig.* 4 the interest is concentrated on the roof with its many gables, each adorned with a pattern of tiled chevrons and tile apexes.

It is still often asserted, by those who have never troubled to investigate, that a concrete village must, by reason of the very nature of the material, be a dull and monotonous conglomeration. At Chepstow we have a concrete town to which there would be no more justice in applying the epithet "dull" than there would be to a town whose predominant material was brick or stone.

The work at these villages was designed and carried out by Mr. Henry E. Farmer, F.R.I.B.A., until March, 1919, when H.M. Office of Works took over the matter. There were then some hundreds of houses completed, in addition to most of the roads in Bulwarks and Pennsylvania. The hospital, electric generating station, and all the shipyard buildings were also finished. Since that time much progress has been made. The contractors are Messrs. Henry Boot & Sons, Ltd., of 12, Lower Grosvenor Place, Westminster, S.W.

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## MEMORANDUM

**The Water Supply of Victoria, B.C.**—The steady increase in the population of Victoria, British Columbia, has rendered the former water supply system inadequate, so that the city authorities have been obliged to undertake the construction of an entirely new scheme. For this scheme, which has recently been completed, Sooke Lake was used as a source of supply. The lake is situated at a distance of about 18 miles north-west of Victoria, at a height of 555 ft. above sea-level, this elevation being sufficient to deliver water to the city by gravity flow alone. The present requirements, it should be mentioned, amount to 16,000,000 imperial gallons daily. A dam has been constructed at the outlet of the lake to raise the water level by 12 ft., and this provides a storage capacity of 3,355,000,000 imperial gallons. From the lake the water is conveyed a distance of 27½ miles through a reinforced concrete pipe to a storage basin formed by a concrete dam, the crest of which is at an elevation of 380 ft. above sea-level. The area of this basin, which is known as the Humpback reservoir, is about 40 acres, and its capacity is 126,000,000 imperial gallons. From the reservoir the water is delivered to the city, a further distance of 10½ miles, through a riveted steel pipe 36 in. in diameter. The concrete pipes, above referred to, form an interesting feature of the work. They were, for the most part, 3 in. in thickness, and were cast in 4-ft. sections at a central mixing plant, in forms carried on cars. The forms used were of steel plate made in sections for easy removal, and after being coated with oil, they were set up on a bell-end baseplate, and the steel wire mesh reinforcing material was placed in position. The concrete having been poured and tamped, the forms were moved on the cars to sheds, where, after being steamed for 3 hours, the forms were removed, and the pipes shifted to another shed for a further 4 hours' steaming. The pipes were then lifted from the cars by a crane, and rolled into a yard for curing. The object of the steaming treatment was to hasten the setting of the concrete so as to release the forms as rapidly as possible, and also to reduce the time required for curing. The joints between the sections were of the interlocking type, giving a smooth internal surface. In joining the sections the bare reinforcement projecting at the ends was lapped together and locked by cement-mortar used to fill the joint. Forms composed of removable flat bands of sheet metal expanded against the inner surface of the pipe were used in pouring the joints. In crossing large valleys pressure pipes, or inverted syphons, were used, and the pipes for these were made 4½ in. thick and had additional reinforcement of steel rods to resist the higher pressures. Reinforced concrete trestles were constructed to carry the pipe over small valleys. The whole of the work was carried out under the personal supervision of Mr. Wynn Meredith, with the co-operation of Mr. C. H. Rust, the Water Commissioner of Victoria, and his assistants.—*Engineering.*

# CALCULATION OF RIGID FRAMES.

By V. ELMONT, B.Sc.

THE great variety of structures in which reinforced concrete nowadays is being used make it imperative for designers to be thoroughly conversant with methods by which the stresses and strains in rigid frames, set up by various loading conditions, can be gauged.

The monolithic nature of this material facilitates the creation of rigidity at the junction of the various members, by correct distribution of steel and concrete, which again leads to greater stability and an economical stress distribution with consequent reduction of the quantity of materials needed. In this connection should be mentioned the danger the rigidity of reinforced concrete building frames entails when the design is not handled with sufficient care and experience. Both theoretical investigations and tests upon completed structures have proved that concrete frames must be designed as rigid. It is therefore necessary, for instance, that the distortions of columns in an ordinary concrete building, due to the obtaining continuity, and the stresses caused thereby, should be carefully investigated for various positions of the superimposed loads on the floors and also for wind pressure ; the bending moments in the columns are frequently very considerable and require special provisions. The fact that a large number of concrete buildings have been designed without such an investigation, and that these buildings have stood up for a number of years furnishes, of course, no means for judging whether they are sufficiently within safe limits of stress for structural work.

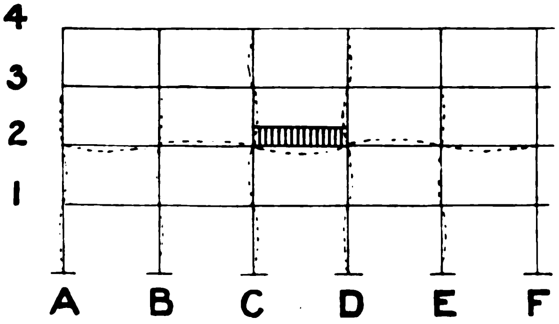


FIG 1.

In a building frame, as the one diagrammatically indicated in *Fig.* 1, is shown how the effect of the load on beam C2–D2 is transmitted to the adjacent beams and columns. By loading the beams B2–C2 and D2–E2 in addition, the bending moments in columns C1–C2 and D1–D2 would practically disappear, while they would be increased if the spans A2–B2 and E2–F2 were loaded at the same time as C2–D2.

The frame has evidently several statically indeterminate conditions—that is to say, that stresses and reactions cannot be expressed purely as functions of the acting loads by applying the three general equations for static equilibrium to the whole system or part of it :

$$\Sigma H=0, \ \Sigma V=0, \text{ and } \Sigma M=0,$$

where $\Sigma H$ is the sum of the horizontal components of all internal and external forces, including reactions, $\Sigma V$ the sum of the vertical components of the same forces and $\Sigma M$ the sum of the moments about any point in the plane of the structure. For computation of the stresses the higher theory of elasticity furnishes the necessary means (the work equations in conjunction with Prof. Maxwell's theorem of reciprocal displacements). In this article it is intended to show engineers who are not familiar with this theory or inexperienced in its practical applications, how the calculation of statically indeterminate structures can be approached from another standpoint and carried out on the basis of the elementary laws and formulæ of mechanics.

To illustrate the method is chosen the simple frame shown in *Fig.* 2. The columns for which the moments of inertia $I_c$ are the same and constant over their whole length, are of equal height and hinged at the feet. The moment of inertia $I_b$ is also constant over the entire length of beam $BC$. The temperature is assumed constant and the supports immovable.

The nature of the structural redundancy of this frame will be realised by resolving the reactions at $A$ and $D$ (see *Fig.* 2), produced by the load on the frame, into their horizontal and vertical components. The latter can be directly calculated by the three static equations, while the horizontal pressures are only determinable to the extent that the difference between them must equal the horizontal components of the external forces ; or if only vertical loads are acting on the frame, the horizontal thrusts $H$ at $A$ and $D$ are the same and acting in opposite directions. The actual value of them cannot be found by the static

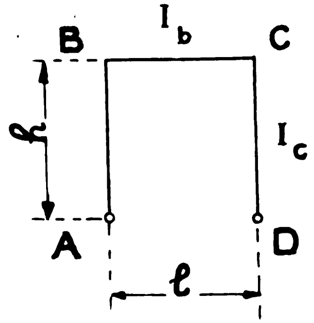


FIG 2.

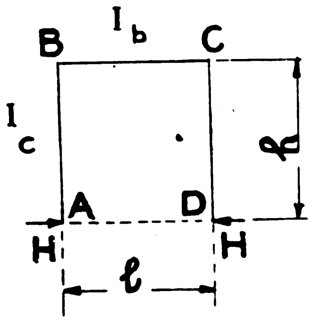


FIG 3.

equations. If, on the other hand, $H$ be known, all normal forces, bending moments and shear stresses can be expressed as simple functions of the external forces and $H$; the structure is said to be externally statically indeterminate with one redundant condition, because there is one reaction more than can be found by the three fundamental equations.

To simplify the investigation the forces for which the frame must be designed are divided into two groups, the first containing the horizontal thrusts $H$ and the second the superimposed loads, dead weight, and the statically determinable reactions. According to the law of the summation of similar partial effects, resulting from various causes, we can ascertain the actual distortions and stresses in the frame by applying each group of forces separately and adding the effects of the two.

The horizontal thrusts acting alone (*Fig.* 3) bend the uprights $AB$ and $CD$ inwards and the beam $BC$ upwards. As a result of these distortions the distance $AD$ is reduced by a length $L$, accruing from three causes:

(1) Each of the uprights acts as a cantilever beam of length $h$ and loaded with a force $H$ at the end. The deflection at this point is, as given in most text books:

$$L_1 = \frac{Hh^3}{3EI_c}$$

where $E$ is the modulus of elasticity.

(2) The beam $BC$, loaded by bending moments $Hh$ acting at each end, bends upwards, the angle between the line $BC$ and the tangent to the deflected beam at $B$ and $C$ being

$$\alpha = \frac{Hhl}{2EI_b}.$$

The uprights are turned the same angle outwards and each of the points $A$ and $D$ in consequence moved laterally a distance

$$L_2 = \alpha h = \frac{Hh^2 l}{2EI_b}$$

(3) The compression of the beam $BC$ by the force $H$ reduces its length (and the distance $AD$) by

$$L_3 = \frac{lH}{EF},$$

where $F$ is the area of the cross-section of beam $BC$.

The resulting shortening of $AD$ is then

$$L = 2L_1 + 2L_2 + L_3 = \frac{2}{3}\frac{Hh^3}{EI_c} + \frac{Hh^2 l}{EI_b} + \frac{Hl}{EF}$$

The forces of the second group, mentioned above, acting alone on the frame must cause a lengthening ($W$) of $AD$ equal to $L$, as the points $A$ and $D$ of the actual frame are fixed in position, from which follows that

$$W = \frac{2}{3} \cdot \frac{Hh^3}{EI_c} + \frac{Hh^2 l}{EI_b} + \frac{Hl}{EF}$$

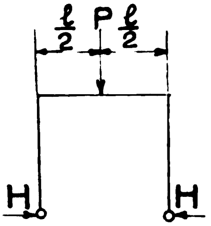
or

$$H = \frac{W}{\frac{2}{3}\frac{h^3}{EI_c} + \frac{h^2 l}{EI_b} + \frac{l}{EF}}.$$

Had the frame in *Fig*. 2 been loaded with $p$ per unit length on the beam $BC$ we should have had

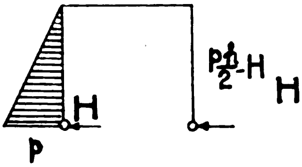
$$W = 2\varphi h,$$

FIG 4.



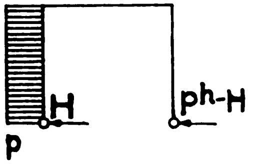
$$H = \frac{3Pl}{8h\,(2r+3)}$$

FIG 5.



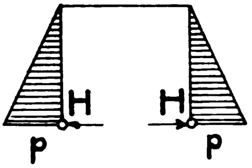
$$H = \frac{ph\,(31r+50)}{40\,(2r+3)}$$

FIG 6.



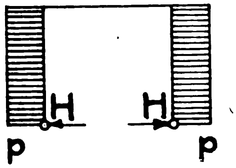
$$H = \frac{ph\,(11r+18)}{8\,(2r+3)}$$

FIG 7.



$$H = \frac{ph\,(11r+20)}{20\,(2r+3)}$$

FIG 8.



$$H = \frac{ph\,(3r+6)}{4\,(2r+3)}$$

where $\varphi$ is the angular deflection at $B$ and $C$, when $H=0$, or in other words $A$ or $D$ are free to move horizontally. For that case

$$\varphi = \frac{pl^3}{24EI_b}$$

and therefore

$$W=2\varphi h=\frac{pl^3h}{12EI_b}$$

and

$$H=\frac{\dfrac{pl^3h}{12EI_b}}{\dfrac{2}{3}\dfrac{h^3}{EI_c}+\dfrac{h^2l}{EI_b}}$$

when omitting the effect due to direct compression as negligible. Introducing

$$r=\frac{I_b}{I_c}\frac{h}{l}$$

the expression for $H$ takes the form

$$H=\frac{pl^2}{4h\,(2r+3)}$$

The values of $H$ for some frequently occurring loading conditions are given in *Figs* 4 to 8.

The two-hinged frames appear in practice in several forms, of which examples are shown in *Figs.* 9 to 16, some of the columns being provided with brackets to support crane girders or balconies and galleries as in theatre buildings, gymnasiums, etc. The principle of calculation is the same as for the frame in *Fig.* 2.

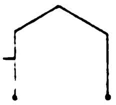


FIG 9.

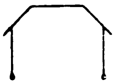


FIG 10.

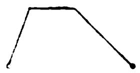


FIG 11.

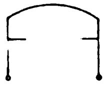


FIG 12.

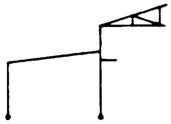


FIG 13.

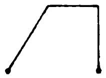


FIG 14.

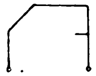


FIG 15.

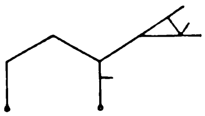


FIG 16.

For the frames, fixed in position and direction at the supports, the computation of distortions and stresses can be carried out in a similar manner as for the two-hinged frame, only it is more complicated, as the fixed frame is externally indeterminate with three redundant conditions the horizontal thrust and two fixing moments, as against one for the hinged frame. Applying again the law of the summation of similar partial effects, the external forces and each of the three redundant quantities are treated separately and the changes of the distance $AD$ (*Fig.* 3) and the turnings of the angles at $A$ and $D$, produced by these various causes, determined. As, however, the uprights are fixed at $A$ and $D$ in the actual frame the length $AD$ must remain unaltered as well as the directions of the uprights at $A$ and $D$; three equations are therefore obtainable through which the values of the three redundant quantities can be ascertained.

For the sake of reference and comparison are summarised in *Fig.* 17 to 22, the horizontal thrusts and fixing moments for fixed frames under the same loads as given above for the hinged ones :

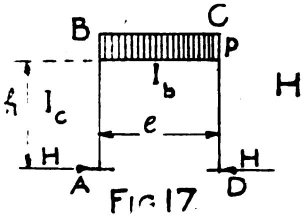


FIG 17

$$H=\frac{pl^2}{4h(r+2)}\quad M_A=M_D=+\frac{pl^2}{12(r+2)}$$

(BENDING-MOMENTS TAKEN AS POSITIVE WHEN PRODUCING TENSION INSIDE)

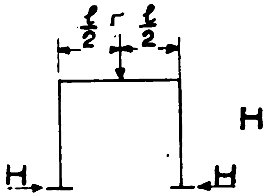


FIG 18.

$$H=\frac{3Pl}{8h(r+2)}\quad M_A=M_D=+\frac{Pl}{8(r+2)}$$

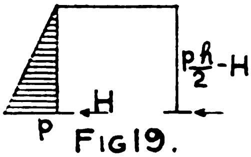


FIG 19.

$$H=\frac{ph(17r+36)}{40(r+2)}$$

$$M_A=-\frac{ph^2}{120}\,\frac{63r^2+151r+28}{(r+2)(6r+1)}$$

$$M_D=+\frac{ph^2}{120}\,\frac{27r^2+49r+12}{(r+2)(6r+1)}$$

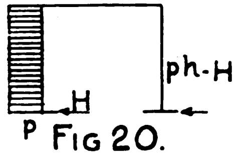


FIG 20.

$$H=\frac{ph(6r+13)}{8(r+2)}$$

$$M_A=-\frac{ph^2}{24}\,\frac{30r^2+73r+15}{(r+2)(6r+1)}$$

$$M_D=+\frac{ph^2}{24}\,\frac{18r^2+35r+9}{(r+2)(6r+1)}$$

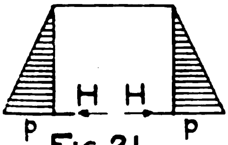


FIG 21.

$$H=\frac{ph(7r+16)}{20(r+2)}\quad M_A=M_D=-\frac{ph^2}{60}\,\frac{18r^2+51r+8}{(r+2)(6r+1)}$$

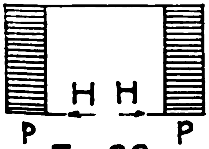


FIG 22.

$$H=\frac{ph(2r+5)}{4(r+2)}\quad M_A=M_D=-\frac{ph^2(r+3)}{12(r+2)}$$

# REINFORCED CONCRETE ROADS AT THE PORTSMOUTH GAS WORKS.

**By S. E. WHITEHEAD, B.Sc.Eng.**

*The reinforced concrete roads laid by the Portsea Island Gas Light Company in connection with their works form an interesting example of concrete road work in this country for industrial works.—ED.*

THE Portsea Island Gas Light Co. is responsible for the maintenance of the public thoroughfare, Green Lane, 1,875 ft. in length. The repair of this road was, of necessity, badly neglected, with the result that it became urgently necessary to relay it immediately after the War. The road is subjected to a fair amount of heavy traffic, including tractors, steam wagons and motor lorries, and it was decided by my chief, Mr. T. Carmichael, Engineer to the Company, to recommend a trial with reinforced concrete. The Eastern half of the road, extending from the Gas Works entrance to the Railway Crossing, was accordingly put down in concrete, the remaining half, over which exactly the same amount of traffic passes, being laid in water-bound macadam, in order to obtain comparative results. The concrete portion measures 725 ft. in length and 22 ft. in width between the kerbs, and is shown in plan in *Fig.* 1.

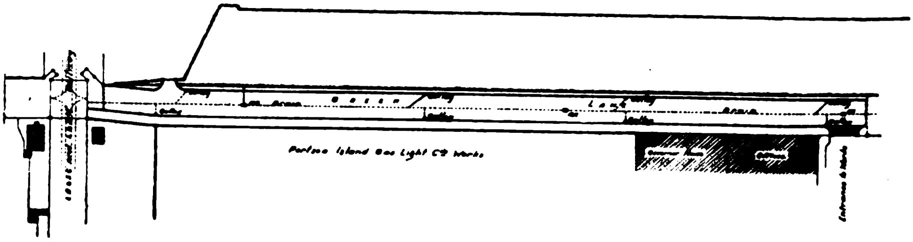


FIG. 1. PLAN OF GREEN LANE TRIAL ROAD.

The existing road was originally of water-bound macadam, but this had been repaired and patched many times and its condition was exceedingly bad.

On the South side of the road was a gravel foot-path bordered by a stone kerb and channel. This foot-path was re-laid and the kerbs replaced on a concrete bed, but the channel was formed in the concrete road, the existing channel stones being lifted and replaced on the North side of the road to form a kerb.

Manholes were provided where necessary at the crown of the road and finished off with two courses of granite setts all round. Gulleys were provided on both sides, bedded in Portland cement concrete foundations, and connected to the existing sewer with 6-in. stone-ware drain pipes.

Work was commenced on the site in June, 1919, and it was fortunately possible to divert the whole of the traffic by making a temporary entrance to the Works at the north-western corner. Accordingly the whole of the road was excavated and scarified to a depth sufficient to form a new bed, all surplus material being screened, and the recovered metal carted away for use on the second half of the road. A good solid foundation was ensured by filling in, watering and ramming any soft places in the bed, the latter being finally finished off to the required camber.

The next operation consisted in laying the reinforcing material, which, in this instance, was No. 9 B.R.C. Fabric. This material was supplied in rolls 7 ft. wide by 80 yds. long, and 3½ widths were used across the road, which ensured a lap of 4 in. between the rolls, together with a fair amount of steel underneath the kerbs on either side. Where the rolls ended transversely a lap of 12 in. was allowed.

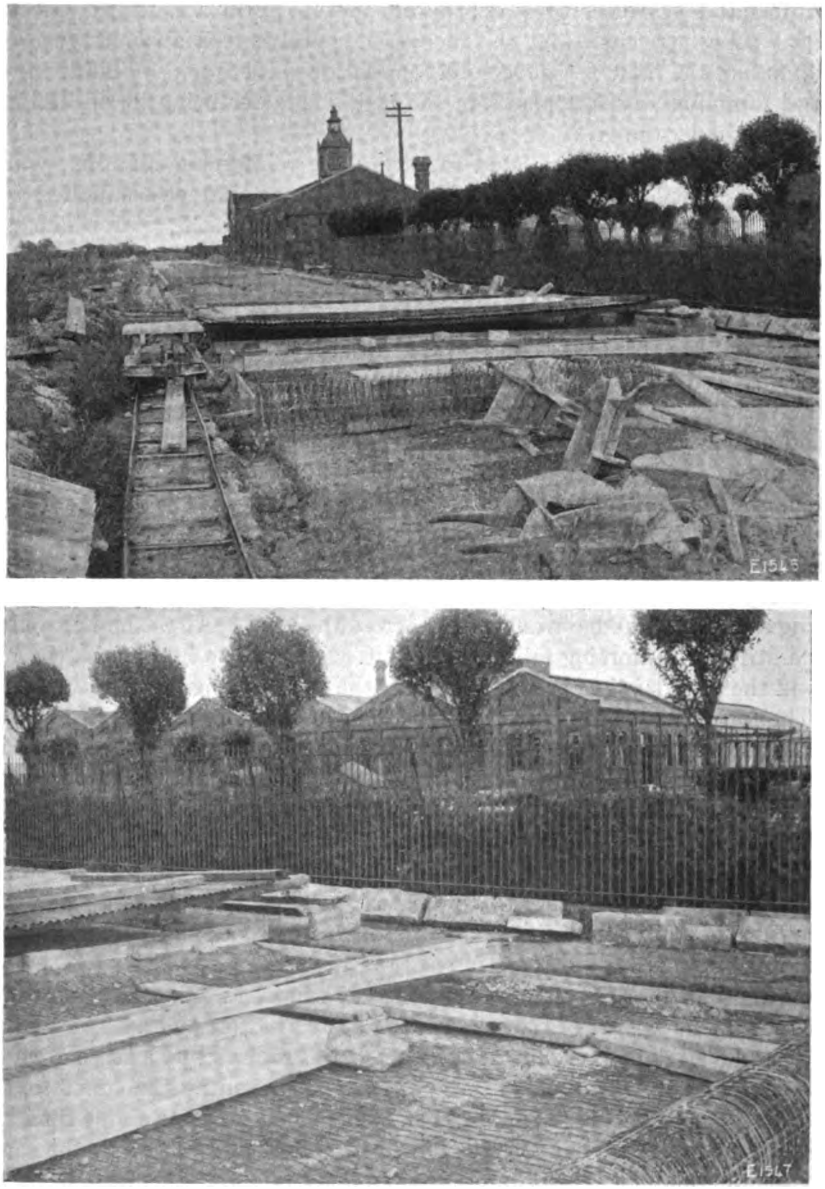
The concrete itself was composed of British Standard Portland cement and shingle dredged from Langstone Harbour, in the vicinity of the Works. The lower 4 in. was mixed in the proportion of 1 in 6, and the upper 2 in. in the proportion of 1 in 3, the shingle for the latter being passed through a screen of ⅜ in. square mesh. On depositing the concrete the reinforcing fabric was lifted and well shaken, and the concrete rammed to the extent of 2 in. below the reinforcement, which was left in all cases 2 in. from the under surface of the concrete. Great care was taken in laying the upper 2 in. of fine concrete before the lower and coarser layer had had sufficient time to set, and the work was finished off each evening at a straight edge transversely across the road. At the end of each day's work a strip of reinforcing fabric, some 3 ft. wide, was so laid across the road as to bond the two days' work together, half the width being left projecting.

The formation of the correct camber was effected by the use of two parallel screeds, placed one on each side of the road, and a camber board or template, faced with hoop-iron, which was dragged backwards and forwards along the screeds after the laying of the concrete in each section. This gave a very good surface, leaving only a few irregularities, which were then floated over with 1 in 3 concrete. Good progress was made by this method, and the weather was very favourable; the average rate of completion being about 30 ft. run per working day. *Figs.* 2 and 3 show the application of this method, and *Fig.* 4 gives a view of the finished road.

As the concrete was laid and the surfaces finished, the work was protected from the sun by means of corrugated iron supported on poles. This temporary roof was moved daily to follow the work and was replaced by a layer of wet sand. This was found to be a very effective method of maturing the concrete, and its surface was kept covered with a layer of well-wetted sand for about three to four weeks after laying. When the concrete had thoroughly matured, the sand was removed and finally a coat of hot dehydrated tar applied, the whole being dusted over with coarse sand.

The road was opened for traffic six weeks after laying the last batch of concrete, or 12 weeks after commencing the work, and the result was considered very satisfactory.

As regards the condition of the road, this leaves nothing to be desired, although it is, of course, too early to give any definite information. But, in comparison with the remaining half of the thoroughfare, which was put down one month later in water-bound macadam, the concrete has certainly stood the test very well, and up to the present has been an entire success.



FIGS. 2 AND 3. METHOD OF LAYING CONCRETE IN GREEN LANE.

In cost, too, the concrete compares very favourably with the macadam road, and a very large saving in maintenance charges is anticipated.

Benefiting by their experience with this trial length of road, the Company are now putting down other roads of greater length inside the works, as shown on the accompanying *Fig.* 5 and marked A, B, and C respectively. The method of laying these roads and their general construction are very similar to those of the trial length, but one or two modifications have been introduced. In the first place the new roads are to be formed with concrete kerbs, no stone being used. The layer of reinforcing fabric, which will again be placed 2 in. from the bottom of the concrete bed, will project under the kerb, and for a distance of 6 in. beyond its outer edge, where the concrete will be formed into a step. This, it is thought, will reduce the stress on the kerb and, as an additional safeguard, a further strip of reinforcing fabric, 1 ft. 6 in. long, is to be laid through the body of the kerb, as shown in *Fig*. 6. B.R.C. Fabric, No. 9, is again being used in roads A and C, but in the case of road B Triangle Mesh is being tried. The latter material is shown in position in *Fig*. 7.

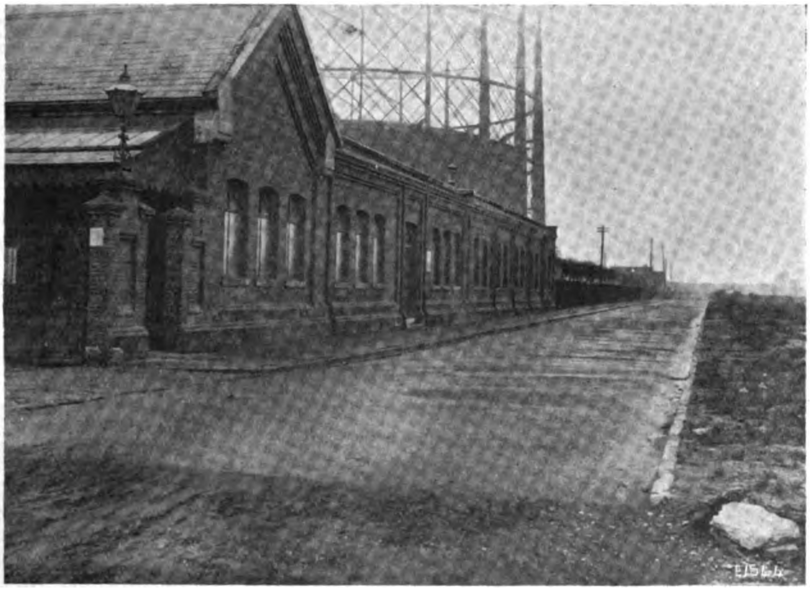


FIG. 4. VIEW OF COMPLETED TRIAL ROAD.

At each end of the trial length of road, the work was finished with two courses of granite setts, laid on a 6-in. bed of Portland cement concrete, and well grouted to form a junction between the concrete paving and the adjoining surface. Although up to the present, this has been quite satisfactory, it has been decided to modify it somewhat in the new roads, the principal reason being the necessity for providing a firm support for very heavy traffic. Accordingly each border of the new roads will be formed into a step, 1 ft. in total depth, upon which the two

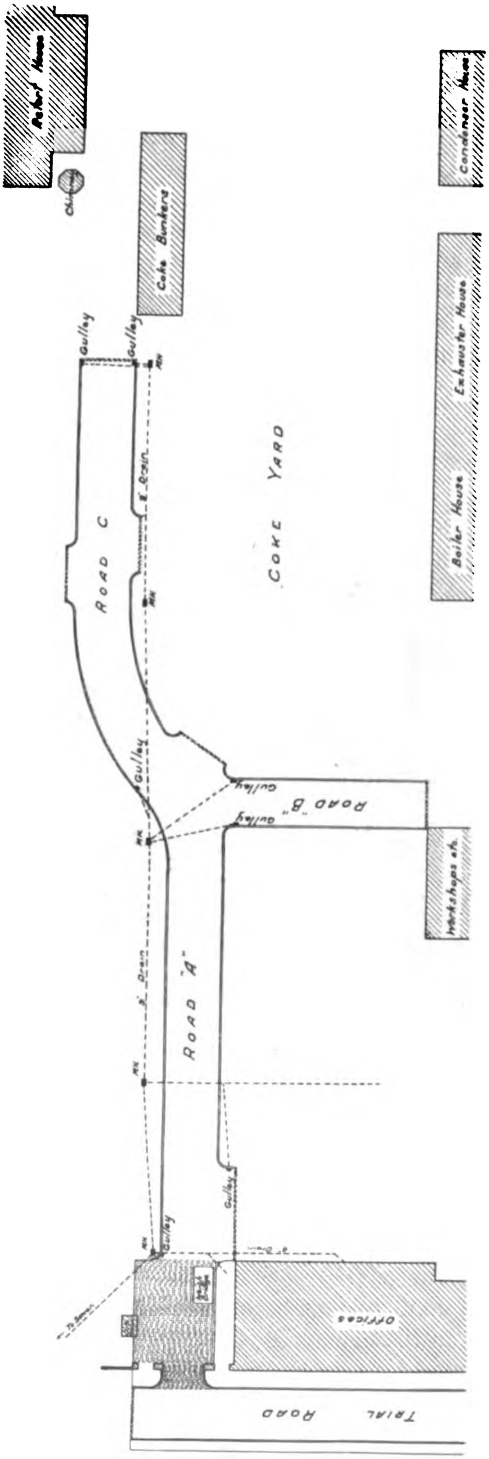


FIG. 5. PLAN OF NEW ROADS—A, B, C.

courses of granite setts will be placed and the reinforcing fabric will be suitably bent under the setts as indicated in *Fig.* 6.

Finally, the question of camber has required some attention. Many concrete roads have been laid with very little camber, and some engineers have specified 1 in 50 for this purpose. Doubtless this will allow water to run off, provided the road can be kept reasonably clean, but a Gas Works yard is usually so muddy as to render the road leading therefrom very needful of attention in this respect. A greater camber was, therefore, given to the trial road—some 4 in. on the total width of 22 ft., or 1 in 33—and this camber is being adhered to in the new roads. It was considered that, although this camber does not keep the roads as clean as could be desired, any greater slope might cause a tendency to side-slipping, and also have the effect of concentrating more of the traffic on the crown of the road. On the whole the camber above mentioned may be considered satisfactory. The work was carried out to the specification and drawings of Mr. T. Carmichael, the Gas Company's Engineer and Manager, by a local contractor.

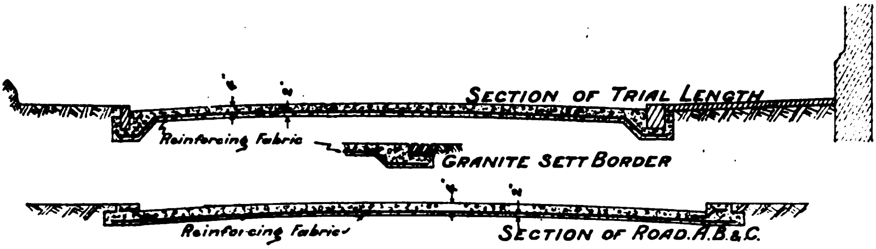


FIG. 6. SECTIONS THROUGH ROADS AND BORDER.

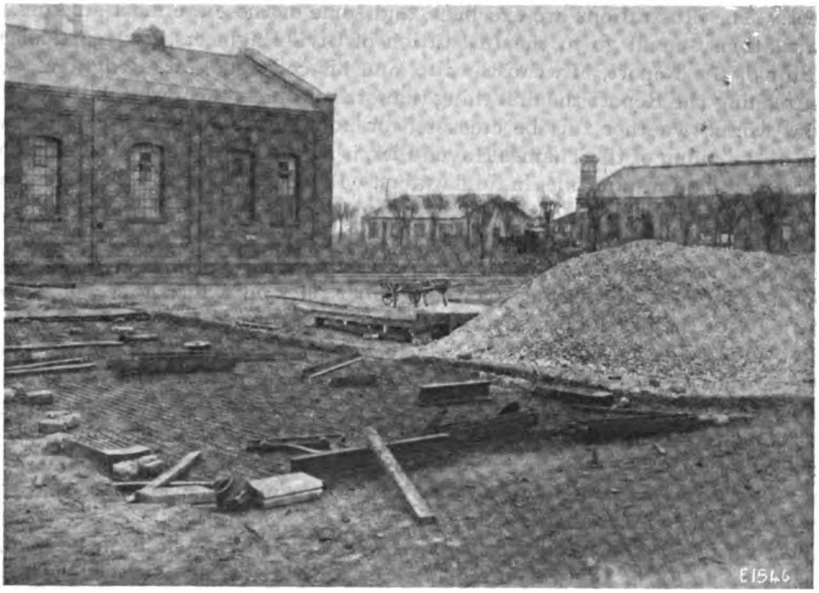


FIG. 7. TRIANGLE MESH IN POSITION ON ROAD B.

# . NOTES ON THE DETERIORATION OF STRUCTURES IN SEA WATER.

## (Report of the Institution of Civil Engineers.)

By Prof. E. R. MATTHEWS, Assoc.M.Inst.C.E., F.R.S.E. (University of London).

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This Report is one of the most comprehensive that has ever been issued by any committee or society or institution on any engineering subject, and it contains a vast amount of useful information which should prove of great value to the maritime engineer. The illustrations are excellent, and some of these are most striking. Our congratulations should go to the Institution of Civil Engineers, and particularly to the editor of the Report, Mr. Crosthwaite, and his colleague, Mr. Redgrave.

In reading the Report the first thing that strikes one is the unsuitability of timber for tidal works, whether this be creosoted or not. Plate XII., which illustrates a portion of the piling of the Thames Haven Pier, is a good example of what may happen in a few years to pitch-pine piles in tidal waters. Plates XXV. and XXVI. are excellent examples of this from New Zealand.

The author has long advocated the use of reinforced concrete in all maritime structures, and especially for piling.

With regard to the wearing away of timber piles on a foreshore where there is shingle: Is not the destruction of the pile more often due to abrasion caused by the shingle being driven against the pile than to the action of the worm?

The author's experience has taught him that if any portion of a timber jetty or groyne is destroyed or damaged by worm, it should never be strengthened by the placing of new timbers against or near the old, for they in a short time will also become infested by the worm.

It is very remarkable that when worms attack a pile they never injure that portion of the pile which is below shore level.

With regard to the creosoting of piles. If a good hard pile is to be used, it is impossible to inject into it anything like the amount of creosote which engineers usually specify. As consultant to the Lowestoft Corporation in connection with the construction of a spur groyne on the south side of the South Pier, to take the place of the old timber groyne, which has now decayed, it is the author's intention to build this almost entirely in reinforced concrete, with main and sheet reinforced concrete piles; and he has approved (with one small exception) the design prepared by the borough surveyor, Mr. Sydney Mobbs. The work will cost about £10,000. He observed recently, when inspecting the foreshore on the north side of the harbour at Lowestoft that (as Mr. Crosthwaite has said on page 131 of the report) while on the South Shore many of the piles of the groynes are very badly damaged by worm (and the illustrations shown on page 130 are not faked), on the North Shore very few of the piles are suffering from the worm. Mr. Mobbs, the author thinks, is right in concluding that the reason why these piles are almost immune from worm is that there is a great deal of shingle on the north side of the harbour, and only sand on the south side, and that the waves, throwing the shingle against the groyne, do not give the larvæa a chance of becoming attached to the piles.

The "teredo" and "limnoria" are extremely active on the South Shore.

Most engineers had come to the conclusion before the issue of this valuable Report that timber could no longer be used advantageously for piling; its life was too short and uncertain, and in tidal waters the alternate wetting and drying soon caused deterioration, so that a more durable material must be used, and some of us consider that reinforced concrete is the ideal material.

There are difficulties, of course, in using reinforced concrete piles; there is the liability of the pile being struck by a vessel coming alongside the jetty, that was the fear of the late Sir Benjamin Baker; a blow of this kind might crack the pile, and this damage might never be observed, and the crack would let in water to the reinforcement and cause this to corrode, or more damage than that might be done by the facework outside of the reinforcement peeling off as shown in plate X. Then there is the matter of abrasion where the piles are on the foreshore, and there is a great deal of shingle. The query was: would the abrasion be such that eventually the reinforcement, which is usually only set in from the outside face of the wall about 2 in., would be laid bare, causing corrosion of the reinforcing bars?

And, finally, we have no certainty as to whether or not the reinforcement generally will in time corrode, and the structure gradually become weaker unknown to us.

In spite of these what we might call detrimental aspects of reinforced concrete, some of us still have great faith in the material; and we suggest that it should be judged, not by an isolated failure (probably one in fifty), but by the many excellent examples of its use in maritime work around our coasts, particularly for jetties, wharves, groynes, breakwaters and piers. The report contains numerous examples and illustrations of these.

Now for a word of friendly criticism of this excellent report.

Several instances of failure of reinforced concrete piles are given in the Report, but in some instances not a word as to why they failed, or as to how failure could in the future be avoided. We should have liked to have had given to us some reasons why in one part of the world reinforced concrete piles have proved eminently successful, and in another part quite a failure, although similar materials were used. Some of us believe that if a good aggregate is used, and suitable sand, with a reliable cement, and the workmanship is satisfactory, that it is impossible for a pile or other part of a structure to fail. There is nothing in the Report to indicate if that is the opinion of those who framed the Report. Has the saltness of the water anything to do with the failure of the piles?

Other information we should have welcomed would have been some suggestions as to:—

(*a*) The best proportions to use in reinforced concrete in maritime work to ensure the best results.

(*b*) The percentage of water that should be used in the mixing of the concrete, and whether a "wet" or a "plastic" mixture is best for the casting of piles; also as to whether these should be cast vertically or horizontally.

(*c*) Whether sea shingle as an aggregate (with sea sand) has any injurious effect upon the reinforcement.

(*d*) The best aggregate to use would also have been valuable information.

(*e*) Some particulars as to how to repair damaged reinforced concrete piles that have been cracked owing to a blow, say, from a barge, would have been welcomed.

(*f*) We think that some experiments might have been made to ascertain if there is a better material than cement to coat reinforcement with so as to ensure that it shall not corrode. The author carried out a series of experiments in 1909 in order to obtain information on this point, and he used :—

1. Cement.
2. Linseed oil.
3. Turpentine.

But the conclusion he arrived at was :—

* " That neat Portland cement, even in thin layers, was an effective preventative of rusting, and that it should be mixed quite wet."

(*g*) The minimum time for curing the blocks after moulding. The author specifies three months.

(*h*) Do those who framed the Report consider that less abrasion of the piles will occur if they are round or octagonal than if square with chamfered angles ?

(*i*) Does the editor of the Report favour hollow sheet piles ? The author is very adverse to these.

And then, lastly, there is an important omission : no tests seem to have been made to ascertain the compressive strength of concrete

(*a*) Submerged in sea water,

(*b*) Alternately in sea water and in air, as in tidal waters,

Compared with concrete that is permanently in air or in fresh water.

The author has carried out numerous experiments on these lines, and in a word his conclusions are that :—

(1) Concrete submerged permanently in sea water has a lower compressive strength than when in air or fresh water, or when alternately in air and in sea water, as in tidal works.

(2) Concrete alternately in air and sea water has less compressive strength than if in air or in fresh water.

Particulars of these tests will be found in a paper recently read by him (April 12th, 1920) before the Society of Engineers on " Flood Prevention Works at Troon, Ayrshire, and the Action of Sea Water on Concrete."

*Generally.*—As we learn more by failures than in any other way, this Report, which is full of instances of failure or deterioration of structures, caused in many instances through unknown circumstances, will be invaluable to the maritime engineer. It suggests to us many topics for research, not the least of which is the cause of serious deterioration in one structure, and no deterioration whatever in another, the two structures being practically identical. The author suggests that insufficient covering of the steel may be the cause of this, as it was in the case of one of the reinforced concrete jetties constructed in the estuary of the Thames by the Port of London Authority, referred to on page 116 of the Report.

Some valuable suggestions on the designing and constructing of maritime structures in reinforced concrete are given by Mr. C. R. S. Kirkpatrick, M.Inst.C.E., the chief engineer to the Port of London Authority, on page 116 ; and if the report contained nothing beyond these practical suggestions, it would be greatly welcomed by those who have to design structures exposed to sea action. The summary given on pages 277 and 178 also contains valuable suggestions.

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* " The Corrosion of Steel Reinforcement in Concrete," by E. R. Matthews. (Paper read before the Society of Engineers, 1909.)

A report such as this is always valuable from the point of view that one gets the benefit of the experience of a number of engineers; all may be doing similar work, and all having their difficulties, failures, successes. When they are set out as they are so splendidly in this report the British engineer practising in this country is able to see what is done in New Zealand or Australia; in Africa or Nova Scotia, in Jamaica, Colombo or Madras; and they can learn of his methods of construction, and of his difficulties. We therefore welcome this most valuable report, which is one of the greatest publications this or any other institution has issued. The whole profession is under an obligation to Mr. Crosthwaite and Mr. Redgrave.

Five years ago Messrs. G. and T. Earle, Ltd., of Wilmington, Hull (cement manufacturers), had some concrete cubes (6 in.) made for the author, and these were formed of various aggregates, and in various proportions, and inserted in each was a short steel rod (round), 3 ins. by ½ in.; the blocks were placed in sea water (in the Bridlington Harbour), and a few days ago, after being there for five years, they were taken from the water and broken.

With one exception only not the slightest corrosion of the metal had taken place; in many cases the rods retained much of the polish which they had when first embedded. I have these samples by me, and they can be seen at University College, Engineering Department, at any time. As to the one exception referred to, this block as a matter of fact was kept in air, and not submerged as the others were in sea water, and the rod showed conclusively that it had been in contact with an air-pocket, and that had caused the corrosion.

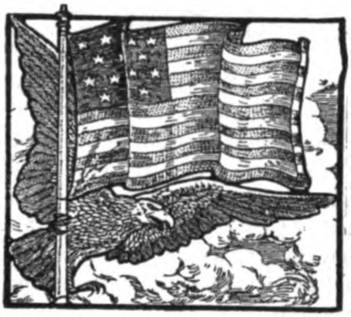
## MEMORANDUM.

**Experimental Roads in Somerset.**—A number of experimental road surfacings are to be laid in the county of Somerset by Lieut.-Col. Stead, the County Surveyor, acting with the approval of the Road Department of the Ministry of Transport.

The experimental work is to be carried out on a length of the Bristol-Exeter main road, about 1½ miles from Bridgwater towards Taunton. This length of road carries considerable traffic of all classes, and the result of the experiments should be of great value. Eight types of road surfacing are to be laid, each section being 220 yd. long by 7 yd. wide, giving an area of 1,540 sup. yd. The section will comprise:—(1) Reinforced concrete; (2) granite macadam bound with "Rocmac"; (3) granite macadam, bound with "Vianex"; (4) Tarmac from Tarmac, Limited, Wolverhampton; (5) tarred limestone; (6) tarred limestone, grouted with "Asphaltmac"; (7) granite macadam, grouted with "Asphaltmac"; (8) monolastic paving by Highways Construction, Limited.

Half the reinforced concrete section will be reinforced with B.R.C. fabric No. 9 and the other half with the Walker-Weston patent interlocked reinforcement. In addition to the above expenditure, four widenings are being carried out at an estimated cost of £500, and in order to give each material a fair test, the whole of the existing road is being thoroughly drained, weak places cut out and make good with clinker and ballast, and the quarters strengthened and shaped with ballast, at an estimated cost of £2,200.

At the present time nothing of the surfacing work has been commenced, but we understand that the work of widening, draining and strengthening the existing road is well in hand.



# NEW DEVELOPMENTS IN SURFACE-TREATED CONCRETE AND STUCCO.

By J. C. PEARSON and J. J. EARLEY.

*The following is an abstract from the Copyright proceedings of the American Concrete Institute, and was read at the Institute's Convention in February of this year. For our illustrations we are indebted to our contemporary "Concrete," U.S.A.—ED.*

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STUDIES of the experimental stucco panels at the Bureau of Standards led to the general conclusion that by adherence to well-established practice structurally sound and durable stucco could be secured, but that a great deal could be, or ought to be, done to improve its appearance. Crazing and map cracking are common to most stuccos, and are especially objectionable on surfaces of fine texture; the monotony of the cold grey cement colour is objectionable, and is only partially relieved by the use of white cement and mortar colours; and finally the muddy appearance (due to cement, or cement and pigment, being too much in evidence) is objectionable from an artistic standpoint.

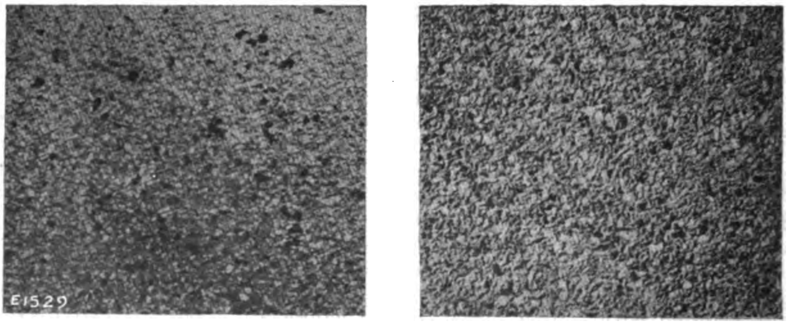


FIG. 1. CONCRETE SURFACES BY EARLEY-PEARSON METHODS.

Consideration of these matters suggested at once the use of less cement, and it became evident that by efforts in this direction improvement in appearance might be obtained. The apparently insurmountable obstacle to this departure from usual practice was, of course, the lack of plasticity in the leaner mixtures. Various methods of overcoming this difficulty were considered, and some experiments were made which indicated that a real improvement might be obtained by substituting fine inert material for a portion of the cement. The easiest way to accomplish this result seemed to be by using blended cements, that is, normal cements ground with a certain percentage of sand, stone-screenings, or other suitable materials. These experiments were never carried very far, however, for it did not seem possible that any method which might be devised for retaining plasticity could bring about the desired result—*viz.*, the elimination of all objectionable features mentioned above.

Serious as was this lack of plasticity in the lean stucco mixtures, it was, after all, something that could be overcome by *work*. This was demonstrated by the fact that mixtures as lean as one part cement to six parts of stone screenings were applied on some of the Bureau of Standards panels, with excellent results. But the improvement in these panels as compared with some of the easier working combinations did not seem great enough to justify the increased cost of application. The question finally arose

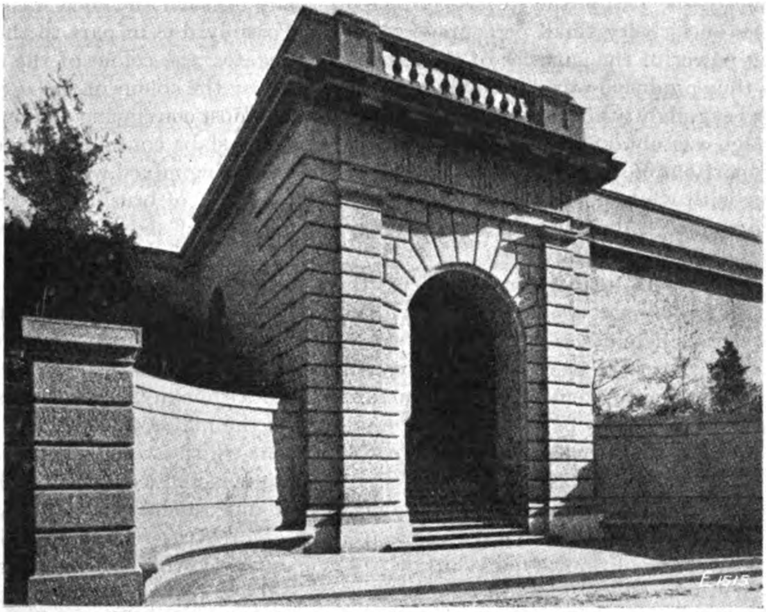


FIG. 2. GENERAL VIEW OF ENTRANCE TO MERIDIAN HILL PARK, WASHINGTON, D.C.

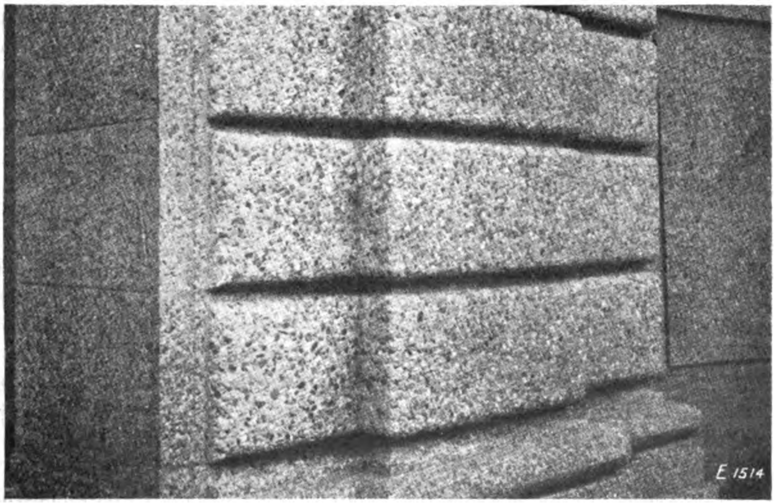


FIG. 3. DETAIL VIEW OF ENTRANCE TO MERIDIAN HILL PARK, WASHINGTON, SHOWING EXPOSED AGGREGATE SURFACES.

whether by careful attention to gradation of the aggregates this improvement in appearance might not be so enhanced that the cost would be a secondary consideration.

This idea came from the fact that Mr. Earley had succeeded in making complicated casts of concrete from specially graded aggregates in such manner that a very large percentage of the area of the treated surface (first wire brushed and then washed) was aggregate, and a very small percentage cement. Possibly due in part to the higher reflecting power of the surfaces of the exposed aggregates, the colour of the concrete surfaces thus produced was determined almost wholly by the colour of the aggregates, and only very slightly affected by the cement itself. A most convincing demonstration of this fact was obtained by constructing two concrete slabs containing exactly the same proportions of specially graded aggregate, the one being mixed with grey cement, the other with white cement. After the surface treatment of brushing and washing had been applied, only an expert could have determined which slab contained the grey cement and which the white.

To digress still further for a moment, this method of obtaining permanent and very pleasing colours in concrete surfaces is such an important item in the development of the processes here described that it is worthy of fuller explanation. Before colour in concrete surfaces can be under artistic control, a technique must be developed which has for its medium the elements of the concrete itself. Although in problems involving appearance aggregate is by reason of its greater bulk the major element, and cement the minor, it is, nevertheless, the colour of the cement which is the natural colour of normal concrete. The reason for this is that the cement is finely ground and deposits, itself, paint-like, over the surfaces of the aggregates and colours the whole mass. If therefore, concrete is to receive its colour from the cement paste, variation must be obtained by the addition of pigments to the cement, following the well-established practice of mixing paints ; but if the aggregate is to be the source of colour; the concrete must be so designed and manipulated as to deposit in the surface the greatest possible amount of aggregate.

Any great degree of success can hardly be expected in colouring concrete through the cement. The choice of colours is restricted by chemical reaction with the cement, which causes them to fade or change ; depth of colour is restricted by strength requirements of the concrete, which limits very closely the amount of pigment which may be added to the cement. Therefore with the choice of colour limited by one requirement and the depth of colour by another, the cement itself must remain dominant.

On the other hand, in colouring concrete through the aggregate all such restrictions are removed, and colours may be obtained from white to black through all the range of possible aggregates.

An examination of drawings done in hard pastelles and of paintings of the impressionist school suggests a technique in colouring which is peculiarly adaptable to the colouring of concrete by means of aggregate. In the pastelles tones are produced by hatching and cross-hatching with lines of pure colour without blending on the surface of the drawing, in the paintings by spotting with pure colours one beside the other, and without blending. In both cases the tones are effected by the blending of the light rays reflected from the picture to the observer. Wonderful depth and clarity of tone are characteristics of this school of colouring, and in it are to be found a great deal of exact knowledge and valuable precedent. When this knowledge is translated in terms of concrete aggregates, it is obvious that if the aggregates are carefully selected and carefully placed, all the elements are present for the successful colouring of concrete surfaces. The results obtained in practice bear out the theory given above, and there is every reason to believe that the aggregate is the proper course of colour for concrete.

Hence it was a most important conception that a similar result might be obtained with stucco. The success of this depended first upon securing a suitable gradation of the stucco aggregate, and second, upon being able to apply such a mixture, once it were satisfactorily compounded. It was known at the outset that these mixtures would be harsh, therefore plasticity no longer played any part in the calculations.

The laboratory programme was fairly simple. The plan consisted simply in working first with concrete mixes in miniature, in which the sizes of cement particles, sand particles and coarse aggregate particles were reduced from the normal sizes in the ratio of about 1 : 10, this being taken as the approximate ratio of the size of particles passing a No. 8 sieve to pebbles one inch in diameter. It was assumed that the density of such mixes would depend mainly on relative sizes of the component particles, with due allowance for the water content. If these mixes appeared to be satisfactory for the purpose, it was assumed that any reduction within the 1 : 10 ratio would also be satisfactory, and the actual reduction to be employed in compounding any given stucco mixture of this type would be as slight as the requirements of texture and the difficulties of application would permit. To make a long story short, these experiments in the laboratory with the miniature concretes were very successful. Not the least important part of the laboratory work was the microscopic examination of the structures of these little concretes, which yielded many valuable suggestions for the gradation in size of particles, and for the proper proportions of the various sizes, to yield the desired effects in the treated surfaces.

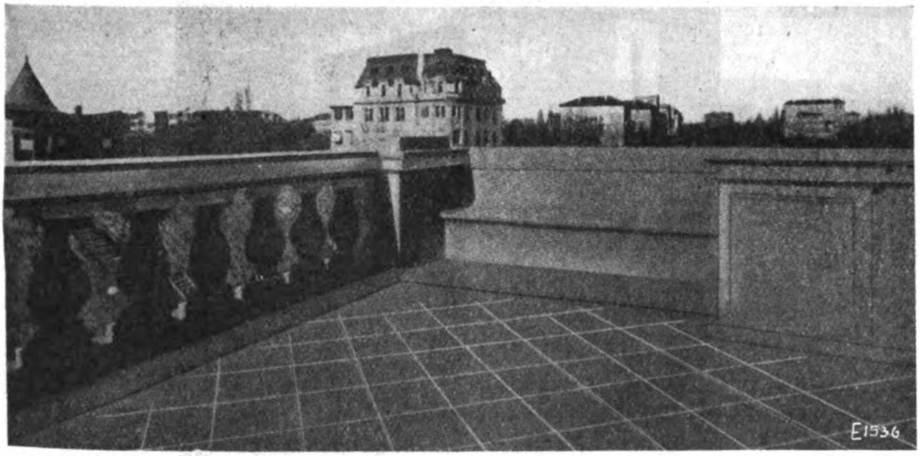


FIG. 4. PRE-CAST CONCRETE WORK AT MERIDIAN HILL PARK.

The first attempt to apply the new product to a vertical wall was not wholly discouraging. Small areas were treated successfully, and eventually a terra cotta tile pent house on one of the new laboratories of the Bureau of Standards was coated with the exposed aggregate stucco. This example was the forerunner of the work illustrated in this paper, and while it is not as free from imperfections as the more recent work, it has attracted most favourable notice. Fortunately, the mechanics who were selected for this work developed a real interest in the new type of finish, and subsequently a pride in the results of their work, which made for very rapid progress in the development of the methods of application and treatment. New requirements in thoroughness of mixing, consistency, and control of the absorption of the undercoats were met, and other improvements in the general process were gradually introduced as essential parts of the routine. Not all of the problems have been solved, but there has been very gratifying progress in the comparatively short time that the new stucco has been applied commercially.

The illustrations accompanying this paper have been selected as typical of Mr. Earley's work in the vicinity of Washington, D.C. They are arranged in nearly chronological order and show the gradual improvement that is being made as experience accumulates.

*Figs.* 2, 3 and 4 are views of the concrete work at Meridian Hill Park, Washington, D.C. The balustrade, seat and planting box are of pre-cast concrete containing Potomac River gravel as coarse aggregate, the concrete tiles are fabricated from black trap rock. The detail of the entrance shown in *Fig* 3 illustrates the use of different textures for architectural scale, but with no variation in colour. The aggregate is Potomac River gravel without additions or modification of any sort.

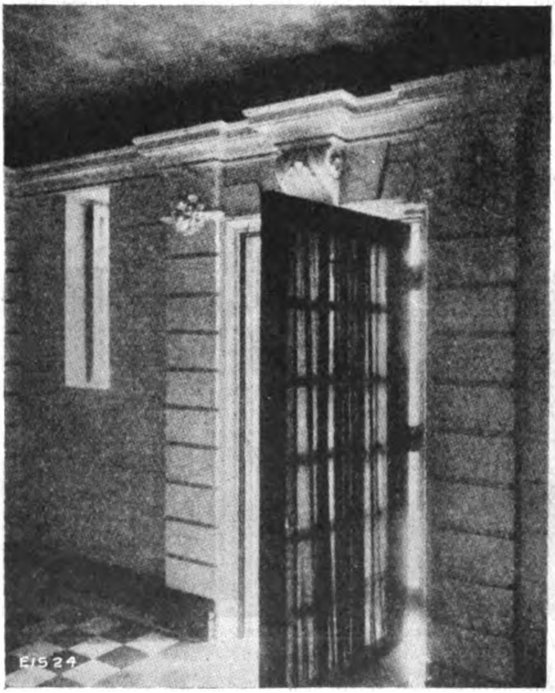


FIG. 5. DETAIL OF VESTIBULE OF PRIVATE RESIDENCE.
COLOUR ALMOST WHITE, WITH OCCASIONAL SPOT OF BROWN.

*Fig.* 5 is a detail view of the vestibule of a private residence. This has recently been completed, and is a very interesting combination of pre-cast work, monolithic concrete, and stucco. The colour is nearly white with an occasional spot of brown, the texture is characteristic of concrete and not of stone, and both colour and texture are uniform throughout.

*Fig.* 6 is an interior view of the Café St. Mark's. The walls are of exposed aggregate stucco, on metal lath, the colour and texture matching that of the pre-cast concrete urns. This is notable as the first commercial application of this type of stucco.

The writers believe that the work here described shows progress in the development of concrete and stucco as materials worthy of a place in the highest type of buildings or structures. It is to be noted especially that none of this work is an imitation of stone. Close inspection shows at a glance that it is concrete, with textures that vary widely, but always characteristic of concrete. Furthermore, the material may be cast in any form the architect may desire, with all details complete; no cutting, tooling, or dressing is required other than the prescribed treatment of cleanly exposing the aggregate. Finally, the material provides a medium for the expression of colour in infinitely greater variety than that which obtains in the natural building stones.

In conclusion the writers would add a word about stucco. The new type of exposed aggregate finish cannot fail to arouse new interest in stucco, as a product, regardless of the nature and treatment of the finishing coat. The product should be more widely used, and the reason it is not more widely used is that it has too often been applied by contractors or mechanics who consider it only as an outside plaster. This paper has attempted to convey the impression that cement stucco is more like concrete than plaster, and that plasticity is not essential. The point the writers wish to emphasise is that the art of applying durable stucco is very different from the art of plastering, and in their opinion stucco will take the place it deserves among building products only when this fact is generally recognised.

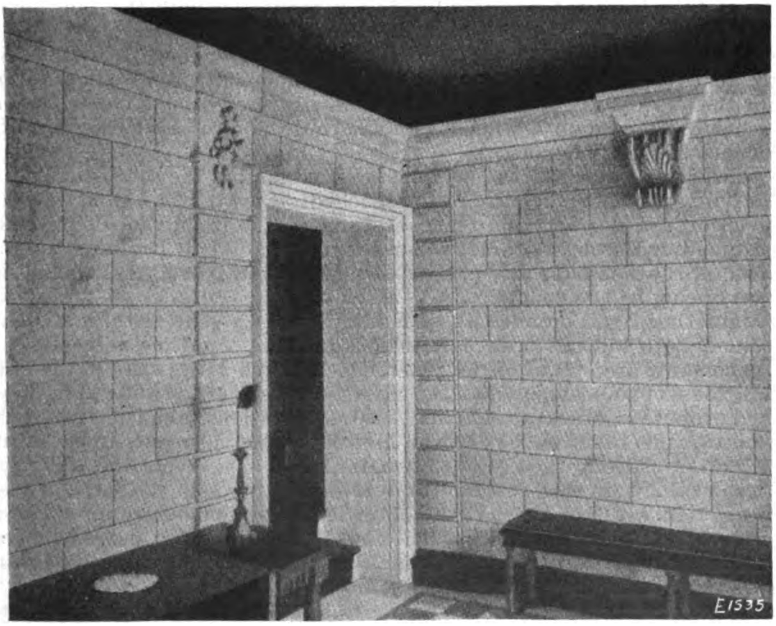
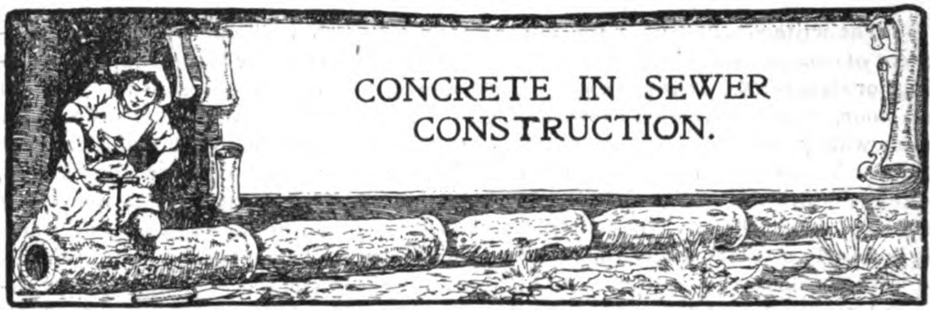


FIG. 6. INTERIOR VIEW OF CAFE, ST. MARK'S, WASHINGTON.



# CONCRETE IN SEWER CONSTRUCTION.

*In another part of this issue we have commented on the absolute need for maintaining a high standard in sanitary engineering, and, as the question is of general importance, we print below a report of the meeting of the London County Council of May 18th.—ED.*

At a recent meeting of the London County Council, Mr. F. R. Anderton (Chairman of the General Purposes Committee) presented the following report regarding the use of concrete in sewer construction in connection with the development of housing estates :—

### USE OF CONCRETE IN SEWER CONSTRUCTION.

2.—We have had referred to us under the provisions of standing order No. 253 the question of the laying of sewers in London in connection with the development of housing estates, particularly in regard to the omission of concrete.

The Main Drainage Committee are reporting correspondence with the Ministry of Health, relative to an application by the Hammersmith Metropolitan Borough Council for the approval of sewers in connection with the borough council's northern housing scheme. The Main Drainage Committee do not consider the result of this correspondence to be satisfactory.

The plans in this case showed no concrete surrounding the sewers except in one road. The borough council, upon being approached, stated that the Ministry of Health would not permit the use of this material. Ultimately the application of the Hammersmith Metropolitan Borough Council was refused by the Main Drainage Committee. In other instances which have arisen the Committee have approved the plans subject to the sewers being laid in concrete.

The Main Drainage Committee point out that, as a general rule, all sewers in London convey both soil and surface drainage, and the Committee's objections to the omission of concrete are set out in the letter, dated March 25th, 1920, to the Ministry. The Committee feel so strongly that the use of concrete is essential that they have refused, and propose to refuse, to sanction sewer applications submitted to the Council under the provisions of section 45 of the Metropolis Management Amendment Act, 1862, which do not specify the use of this material. In this event the Ministry must take the responsibility in each instance of over-riding the Council's decision.

In connection with the matter, the Main Drainage Committee have considered the question of the drainage of the Council's Roehampton Estate and they have been in communication with the Housing Committee thereon. The Housing Committee have stated that, until the principle is definitely established, it is proposed to use concrete in the construction of the sewers on this estate, and that the Finance Committee has been asked to concur in the proposal.

The plans of the drainage of the Council's Roehampton Estate have not yet been submitted by the Wandsworth Metropolitan Borough Council for the Council's approval. We are informed that the plans are before the borough council, which is offering the same objection as that above stated. The Main Drainage Committee have informed the Finance Committee that they are of opinion that the use of concrete in connection with the construction of sewers on the Council's housing estate should be agreed to so that the position which the Main Drainage Committee have taken up on behalf of the Council may not be prejudicially affected. Otherwise the Committee feel that, in order to secure equal treatment to all applicants, they will have to refuse approval to any application from the Wandsworth Borough Council which does not involve the use of concrete.

The Finance Committee understand that if the pipe sewers on the Roehampton estate are laid in concrete it will involve an additional expenditure of about £8,000 which will not rank for State financial assistance in respect of an approved housing scheme. The Finance Committee are strongly of opinion that the Council should definitely adhere to the financial principle that it will not incur expenditure on housing schemes unless such expenditure will rank for State financial assistance. The Finance Committee have urged the Housing Committee not to proceed with the laying of sewers in concrete pending the decision of the matter at issue.

It will be seen that there is not necessarily any essential difference between the views held by the two Committees. Indeed, we find ourselves in agreement with both the principles held, for on the one hand we think that it would be disastrous to the public health of the community if the use of concrete in sewers were dispensed with as suggested by the Ministry of Health, and, on the other hand, we feel strongly that expenditure incurred in the use of concrete should rank for State financial assistance. In the result, we feel so strongly that this position should be secured that we recommend that the Council should ask the Minister of Health to receive a deputation in order that the Council's views in the matter may be placed before him. We suggest that the London Members of Parliament should be asked to be present when the deputation is received. We recommend—

(*a*) That in the opinion of the Council the omission of concrete in the laying of sewers constructed in the administrative County of London is undesirable, and should not be allowed.

(*b*) That expenditure incurred in laying sewers in concrete should rank for State financial assisatance.

(*c*) That copies of the foregoing resolutions (*a*) and (*b*) be forwarded to the Minister of Health and that he be asked to receive a deputation from the Council in order that the Council may place before him its views on the subject of the use of concrete in the construction of sewers.

(*d*) That the deputation referred to in the foregoing resolution (*c*) do consist of the members of the Building Acts, Housing and Main Drainage Committees and Mr. Harry Gosling, and that Members of Parliament representing London constituencies be invited to attend when the deputation is received.

**Mr. J. Herbert Hunter** (Chairman of the Main Drainage Committee) also presented a Report on the same subject in the following terms :—

### DRAINAGE OF HOUSING ESTATES.

1.—We have had under consideration an application submitted by the Hammersmith Metropolitan Borough Council for the approval of sewers in connection with the borough council's northern housing scheme, in which, with one exception, no provision is made for the use of concrete. Upon attention being called to the matter the borough council stated that the omission had been made by direction of the Ministry of Health. We thereupon communicated with the Ministry as follows—

County Hall, Spring Gardens, S.W.1.,
March 25th, 1920.

SIR,—The Council has had under consideration an application by the Hammersmith Metropolitan Borough Council for approval of sewers in connection with the laying out of the borough council's northern housing scheme. Except in one instance, the plans submitted in respect of the above-mentioned housing scheme show that no concrete is proposed to be used under or around the pipe sewers, and in response to enquiries the Council has been informed that the omission of concrete is in accordance with the instructions of the Ministry of Health.

The use of concrete in the construction of house drains is specified in the Drainage By-laws made by the Council under the provisions of Section 202 of the Metropolis Management Act, 1855. Under Section 45 of the same Act the plans of local sewers must be submitted to the Council for its approval, and, as a condition to such approval, it has for many years required that pipe sewers shall be bedded upon and entirely surrounded by concrete.

In the Council's opinion, the value of the use of concrete in connection with the construction of sewers and drains has been abundantly proved, and the Council views with alarm any attempt to cheapen the development of housing estates by the omission of such a safeguard. To lay pipes merely upon the bed of the trench is more than likely to lead to complications in the future, and it is a matter of much doubt whether such a method of construction would ultimately even be pecuniarily economical. The question must also be regarded from a health point of view. Sewers laid as proposed by the Ministry would be extremely liable to become discontinuous and soakage of sewage into the soil would follow with results which are known to be serious. Not only so, but the sewers would admit sub-soil water, and extra work would thus be thrown upon the main drainage system.

In the circumstances, the Council feels that it must definitely refuse to associate itself with the adoption of such proposals, and, if the Ministry persists in its present attitude, the Ministry must accept full responsibility therefor.

Pending further consideration of the matter, the Council is not prepared to approve the plans submitted by the Hammersmith Metropolitan Borough Council, and it will therefore be glad to hear further at an early date as to the action which the Ministry proposes to take in the matter.

A similar question has arisen in connection with the construction of sewers on the Council's housing estate at Roehampton and forms the subject of a separate letter which is being sent to the Ministry.

I am, etc.,
(Signed) JAMES BIRD,
*Clerk of the Council.*

The Secretary, Ministry of Health.

In reply the following letter was received :—

Ministry of Health, Whitehall, S.W.1.,
April 15th, 1920.

SIR,—I am directed by the Ministry of Health to advert to your letter of the 25th ultimo (C. 14561), with reference to the use of concrete in connection with the construction of sewers and drains on housing estates.

The Ministry have given full consideration to the representations made in your letter and to those which were made by officers of the County Council at Conferences here in connection with the lay-out of the Roehampton Housing Estate, but they feel that the views expressed in their letter of the 22nd ultimo are fully warranted and they accept full responsibility therefor.

I am, etc.,
(Signed) A. E. GODDARD,
*for Assistant Secretary.*

The Clerk of the London County Council.

The views of the Ministry in the matter as expressed in their letter of March 22nd, 1920, are as follows :—

Ministry of Health, Whitehall, S.W.1.,
March 22nd, 1920.

SIR,

ROEHAMPTON SCHEME.

. . . . . . . . . . . . . . . . . . . . . . . .

In connection with the development of sites for housing purposes, it is not considered necessary to use concrete for bedding or encasing salt glazed ware pipes sewers except in the following circumstances :—

(*a*) Where the nature of the ground provides a bad foundation, the pipe to be bedded on concrete at least 6 inches thick, haunched up to the centre of the pipe.

(*b*) Where the depth of cover above the pipe exceeds 14 feet or is less than 4 feet in roads, or 3 feet in fields or other places liable to be used by carts, etc., the pipes to be completely encased in concrete at least 6 inches thick.

(*c*) Where the internal diameter of the pipe exceeds 15 inches, it may be strengthened with concrete where considered necessary.

The Minister suggests that this course should be followed in the present scheme.

. . . . . . . . . . . . . . . . . . . . . . . .

I am, etc.,
(Signed) I. G. GIBBON.

The Clerk of the London County Council.

Notwithstanding the attitude of the Ministry, we feel that we must adhere to our views, and we have informed the Hammersmith Metropolitan Borough Council that we are unable to approve the plans submitted by them having regard to the omission of concrete. In other respects we have no objections to offer to the plans.

As regards the sewers to be laid in connection with the development of the Council's own estates we have communicated our views to the General Purposes Committee, who are reporting upon the matter.

We report the facts for the information of the Council.

**Miss A. Susan Lawrence** (Labour Party) said that London was a City peculiarly exposed to health dangers; hardly a year passed when it was not visited by cholera, typhoid was more or less with them, and the only thing which protected London from some of the frightful epidemics with which the middle of last century was only too familiar was the excellence of its drainage and water systems. Nothing more shameful could be imagined than that the Ministry of Health should insist that the County Council and Borough Councils should lay drains which were not above suspicion, and she was glad that they were to resist the Ministry in its attempt to lay hands upon the "Ark of the Covenant," their drainage system. The Council would win the battle easily, and in so doing would win the battle of Manchester, Liverpool, Birmingham and every building authority throughout the country.

**Mr. G. H. Hulme**, the leader of the Municipal Reform Party, said that, while something might be said for the action of the Ministry from the point of view of economy, the Council had to consider first of all its special responsibilities.

**Mr. Hunter** said it was no use putting up houses unless they had efficient drains, and the real reason why London had been fairly exempt from large epidemics in the last 60 or 70 years was because their wise predecessors insisted on all drains and sewers being laid in concrete. The Committee insisted on concrete because they believed it would be for the good of the health of the people of London, and because they had, within the last year, passed a storm relief scheme of five or six million pounds. In heavy storms, drains and sewers laid without concrete would sink, resulting in heavy flooding and much damage.

**Mr. Edwin Evans**, speaking from the building point of view, said it had been the custom to lay drains with concrete. The drains were not always covered with concrete; it depended on the nature of the soil; with some soils concrete was scarcely necessary. The Council was planting trees on its housing estates. There was nothing more dangerous than to lay a drain on virgin soil, without any protection, when planting trees. It was essential in some cases that they should have concrete all round the drains, in other cases only for bedding.

The recommendations were unanimously adopted.

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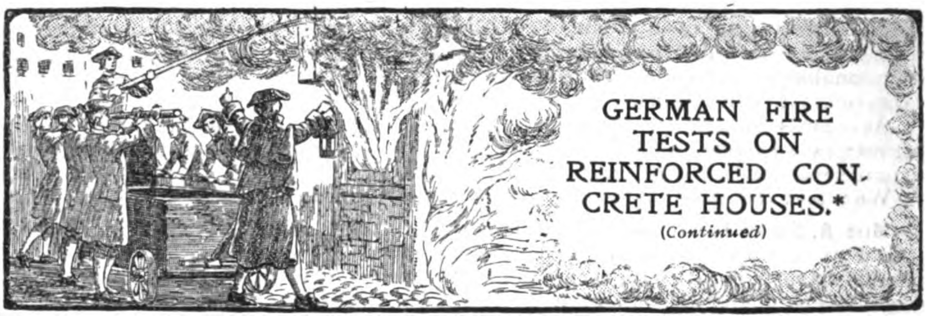
## MEMORANDA.

**A New Bridge at Kentford.**—At Kentford, on the road between Bury St. Edmund's and Newmarket, a new bridge has lately been erected, thus considerably improving one of the best highways in East Anglia. The new bridge is situate about nine miles and a half from Bury, and four and a half miles from Newmarket.

The work has been carried out under the supervision and in accordance with the design of the West Suffolk County Surveyor (Captain W. Lionel Jenkins, R.E.). The width between abutments is the same as the old bridge, but there is only one intermediate pier. The foundations are of concrete, with brick abutments, while the floor and parapets are of reinforced concrete. The available carriage-way is 23 ft.; the gradient on the Bury side is 1 in 74 and on the Newmarket side 1 in 42.

**Disabled Men's Exhibition.**—We are asked by the Ministry of Labour to announce that on July 21st an exhibition, run entirely by disabled men, is to be opened at the Central Hall, Westminster, in order to demonstrate the value of the training which ex-Service men disabled in the war have been receiving under the schemes administered by the Ministry of Labour. Amongst the trades represented will be boot-making, watch and clock repairing, basket-making, tailoring, hairdressing, the building trades, including masonry and ornamental plaster work, the furniture trades, engineering, jewellery, and so on. Working exhibits will be a feature.

The exhibition—to which a small entrance fee will be charged—will be open daily from 11 a.m. to 9 p.m.



# GERMAN FIRE TESTS ON REINFORCED CONCRETE HOUSES.*

(Continued)

By ARTHUR HOLMES, D.Sc., A.R.C.S., F.G.S.

*Geological Department, Imperial College, South Kensington; Technical Assistant to the British Fire Prevention Committee.*

*The illustrations in this article are reproduced from the report on the tests mentioned in the footnote on this page. In the May number the preliminary preparations for the tests were described.—ED.*

**The Fire Tests.**—The maximum temperatures reached in different parts of the two houses are set forth below. Each fire was begun about 11 a.m., and to facilitate comparison between the behaviour of each house during the tests the observations made are arranged side by side together with the times (measured from the commencement) at which they were made.

| Fire Tests. | Method of Measurement | Maximum Temperatures | |
|---|---|---|---|
| | | House III. | House IV. |
| | | ° C. | ° C. |
| 1. In upper storey .. | Thermo-element $T_1$ east side .. | 1000 | 700 |
| | ,, $T_2$ west side .. | 740 | 800 |
| 2. In lower storey .. | Thermo-element $T_1$ east side .. | 1050 | 1020 |
| | Fusion of alloys east side .. | 1120+ | 1020+ |
| | Thermo-element $T_2$ south side | 1150 | 1100 |
| | Fusion of alloys north side .. | 954+ | 1020+ |
| | ,, ,, west side .. | 1100+ | 1100+ |

OBSERVATIONS DURING FIRE IN UPPER STOREY.

| Minutes from start. | HOUSE NO. III. (BASALT, ETC.). | HOUSE NO. IV. (GRANITE, ETC.). |
|---|---|---|
| 0 | Fire started. | Fire started. |
| 6 | The weight on the north side falls, the wire rope having snapped | The wooden shutters on the east begin to burn |
| 8 | The wooden shutters on the north burn and begin to fall down | Large cracks appear in the vault of the roof. |
| 11 | The glass of both the wired windows of the lower storey show cracks | Flames pass through the window on the south |
| 12 | The weight on the south side falls | |
| 14 | The wooden shutters on the east burn | Cracks appear above the cornice on all four gables. |
| 16 | Cracks appear on east and north walls and water vapour emerges, staining the cracks | The weight on the south falls and several flakes spall from the panes of the lower window |

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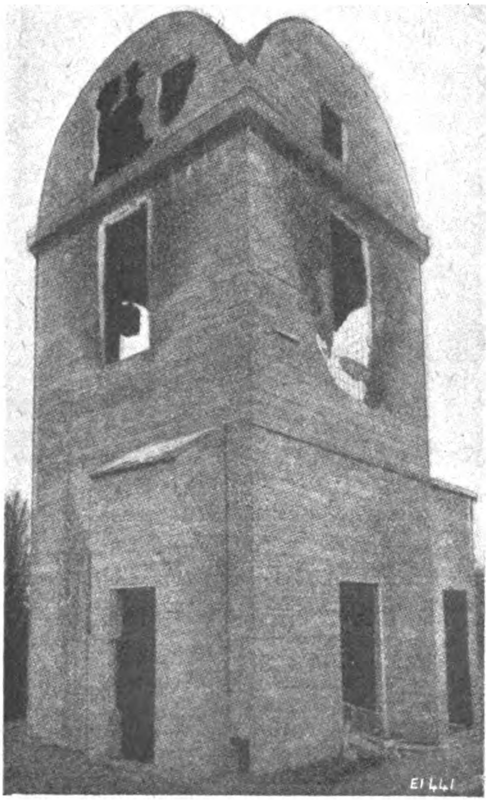
* Brandproben an Eisenbetonbauton, 1914-15. II. Bericht, Erstattet von Prof. M. Gary. Deutscher Ausschuss für Eisenbeton, Heft 33, pp. 66. Berlin, 1916.

| Minutes from Start. | | |
|---|---|---|
| 18 | ... ... ... ... | The weight on the north falls. |
| 19 | Parts of the shutters on the south fall. | |
| 20 | Small glass splinters fly off from the south wired window. The cracks in the walls enlarge. | |
| 21 | ... ... ... ... | Cracks appear in the west gable. |
| 22 | A stronger crack appears in the east gable, extending vertically from roof to cornice. | |
| 24 | Strong cracks appear in the cross-vault of the roof. | Much burning wood falls on the iron staircase, and the steps are slightly bent. |
| 26 | A crack appears in the south wall. See Note below. | Cracks appear in the east gable, and further flaking from the lower window occurs. |
| 28 | ... ... ... ... | The north gable shows cracks, and a crack also appears in the south wall of the lower storey. |
| 33 | ... ... ... ... | With a loud report a large piece (60 cm. by 60 cm.) of the wall of the east gable springs out. (See *Fig.* 2.) |



EAST. FIG. 2. NORTH.

APPEARANCE OF HOUSE IV. AFTER THE UPPER FIRE.

| Minutes from start. | | |
|---|---|---|
| 34 | ... ... ... ... | With a similar explosion another smaller piece springs from the same wall, the fragments being widely scattered. |
| 36 | ... ... ... ... | The hole in the east gable is enlarged by the breaking away of other pieces. |
| 41 | ... ... ... ... | With a violent detonation large pieces fall from the north wall. (See *Figs*. 2 and 3.) |
| 71 | ... ... ... ... | From both sides of the window on the west large pieces commence to fall (See *Fig*. 3.) |
| 105 | Fire extinguished. | Fire extinguished. |

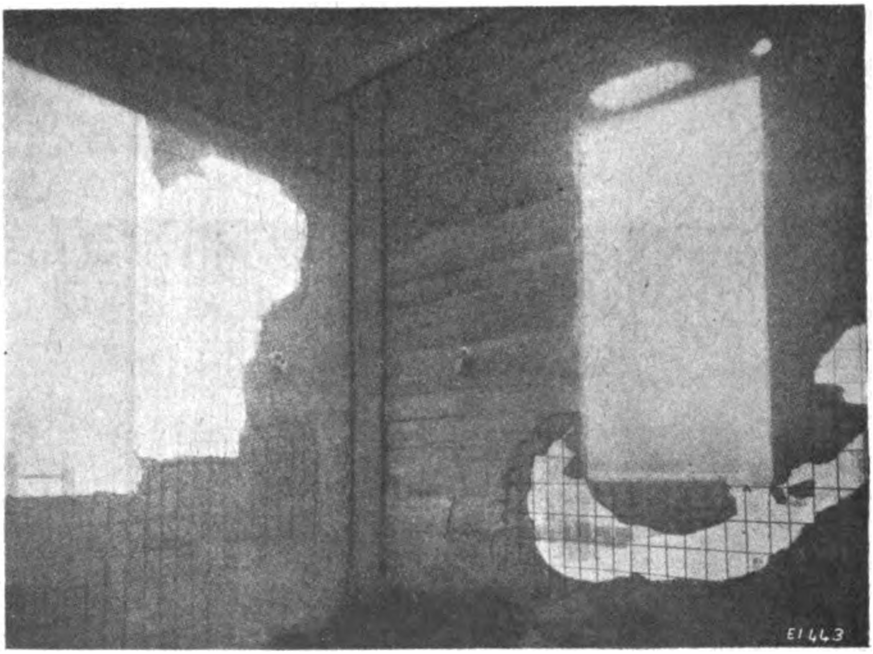


Fig. 3.

West. North.

Interior View of part of House IV. showing Exposure of Reinforcement after the Upper Fire.

OBSERVATIONS DURING FIRE IN LOWER STOREY.

| | House No. III. (Basalt, etc.). | House No. IV. (Granite, etc.). |
|---|---|---|
| 0 | Fire started. | Fire started. |
| 6 | ... ... ... ... | The weight on the south side falls. |
| 7 | The weight on the south side falls. | |
| 8 | ... ... ... ... | Fragments of glass fall from the west window. |
| 9 | The weight on the north side falls. | |
| 10 | ... ... ... ... | The weight on the north side falls. |

| Minutes from start. | | |
|---|---|---|
| 11 | The wired-glass of the east window softens and bends strongly outwards. | |
| 13 | A strong vertical crack appears in the north wall. | |
| 17 | ... ... ... ... | Numerous vertical and horizontal cracks appear in the north wall and fumes pass through. |
| 18 | ... ... ... ... | Similar cracks appear in the east wall. |
| 21 | ... ... ... ... | The west wall bends outwards on both sides of the window. |
| 24 | ... ... ... ... | The west wall develops a strong crack and several smaller cracks, from all of which moisture oozes. |
| 25 | Cracks appear in the brick wall, most marked near the corners. The south wall also cracks. | The cracks of the east wall are enlarged. |
| 26 | The glass of the west window begins to melt. The plain concrete walls become damp. | |

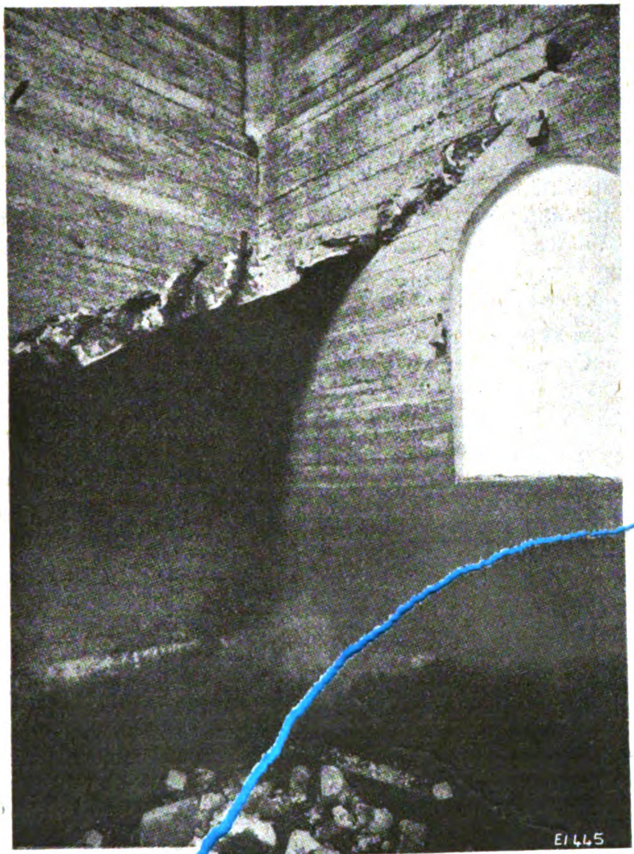


FIG. 4. UPPER FLIGHT OF STAIRCASE IN HOUSE III., AFTER THE LOWER FIRE, SHOWING FAILURE OF SANDSTONE STEPS.

| Minutes from start. | | |
|---|---|---|
| 27 | ... ... ... ... | The west wall is more strongly bent outwards. |
| 28 | Vapour begins to escape from the walls. | |
| 30 | The glass of the east window begins to melt. | |
| 32 | Sandstone steps from the upper part of the staircase fall. (See *Fig.* 4.) | |
| 35 | ... ... ... ... | The glass of the east window begins to melt. |
| 36 | ... ... ... ... | The iron steps of the upper part of the staircase are strongly bent. |
| 40 | ... ... ... ... | The glass of the west window begins to melt and fragments of glass fly off. |

**Note on House III.**—The temperature of the interior reached its maximum after twenty-six minutes and then slowly began to decline. An attempt was made to keep the temperature as high as possible. However, except for the gradual widening of the cracks already formed, no further changes were noticed. After the fire was quenched most of the cracks closed up.

**Note on House IV.**—The application of water destroyed the few remaining block-glass panes, but the cement lattice-work of the windows still remained whole. Apparently no damage was suffered by the reinforced concrete steps. The middle landing was bent and slightly cracked, and spalled on the under surface. The wrought-iron steps above were all bent downwards, and it was just possible with difficulty to walk on them after they had cooled. The most striking point to notice, however, is the fact that the explosive disintegration suffered by the upper walls (single reinforcement) in the first fire was not experienced by the lower walls (double reinforcement) in the second fire.

*(To be concluded.)*

## MEMORANDUM.

**An Institute of Physics.**—The need has long been felt for a corporate body analogous to the Institute of Chemistry which would represent the profession and strengthen the position of workers engaged in physics, and which would also form a bond between the various societies interested. It is one of the aims of the new Institute of Physics to secure recognition of the position and value of the physicist, and it is felt that such recognition can only be obtained by the co-operative action of all the physicists in the country.

The Institute has been founded by the co-operation in the first instance of The Faraday Society, The Optical Society and The Physical Society of London, and the first board is constituted from representatives appointed by the councils of these societies.

The first president of the Institute is Sir Richard Glazebrook, K.C.B., F.R.S. ; Sir Robert Hadfield, Bart., F.R.S., is treasurer, and Professor A. W. Porter, F.R.S., honorary secretary.

Further particulars and forms of application for membership may be obtained from the secretary, Mr. F. S. Spiers, at 10, Essex Street, Strand, W.C.2.

RECENT VIEWS ON CONCRETE & REINFORCED CONCRETE.
Recent Papers and Discussions.

*It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.—ED.*

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### *THE CONCRETE INSTITUTE.*

# THE CONSISTENCY OF PORTLAND CEMENT, MORTAR, AND CONCRETE.

By H. G. LLOYD, A.C.G.I.

*Abstract from a Paper read at the Ninety-fourth Ordinary General Meeting of the Concrete Institute, on April 22nd. The President, Mr. H. D. Searles-Wood, was in the Chair.*

## INTRODUCTION.

THE object of this Paper is to describe a simple means of ascertaining the quantity of water required when mixing mortar or concrete.

If a definite weight of Portland cement, its requisite amount of water, and an equal quantity of dry clean sand are mixed together, it is at once apparent that the resultant mortar is of a very different consistency from that of the neat Portland cement. What has occurred is that the dry sand has taken some of the water and thereby robbed the cement of part of its full amount, with the consequence that the cement has not been able to set to the best advantage. It is therefore clear that a certain amount of water must be added to that required by the Portland cement, in order that the sand may not take any of that needed by the cement. This quantity must also be such that it is not in excess of that which can be retained by the sand. If, however, the surfaces of the grains of sand are just damp then any cement paste which may come in contact with such grains will not lose its water to, or take up water from, the sand, and the object desired will be attained.

## CONSISTENCY.

It should be borne in mind that the term, consistency, as used in connection with Portland cement, mortars and concretes does not indicate the quantity of water which is added to the dry materials; it is simply the state of these materials, immediately after their admixture with water.

It therefore follows that consistency is itself a variable, and must be qualified, since it implies an indefinite degree of density.

## CONSISTENCY OF NEAT PORTLAND CEMENT.

The consistency of neat Portland cement is sometimes described as like "butter" or "putty" or some other plastic material. It is also sometimes referred to as the proper consistency. These descriptions, whilst giving a general idea of consistency, are not definite enough for the present purpose.

In this case the required consistency is such that the Portland cement contains the least quantity of water—no more and no less—in order for it to set completely. For convenience this may be called the "standard" consistency.

The quantity of water which will produce standard consistency varies with different cements. It is usually expressed as a percentage by weight of the Portland cement.

The standard consistency may be ascertained experimentally by means of the Boulogne method or the Vicat apparatus.

### CONSISTENCY OF MORTAR.

In order to arrive at the percentage by weight of water necessary to be added to the Portland cement and sand, it is customary to mix the dry materials and then to add a weight of water, known to be less than the requisite amount, and so to continue adding further small quantities until the physical characteristics of the mortar indicate the desired consistency.

This object may be attained by a simpler method, if it is approached in a different manner. This may be best explained by an example. Suppose that a test on a sample of Portland cement is to be made in accordance with the British Standard (1915) Portland Cement Specification and that eventually the sample complies with all the requirements. Suppose also that it is known that the Portland cement requires 22 per cent. of water. The mortar briquettes are about to be made in the proportion of three parts by weight of Leighton Buzzard standard sand to one part by weight of Portland cement. What quantity of water must be added to the dry materials, in order to obtain what may be called the "standard" consistency for this particular cement and sand? If the ingredients are considered separately, it will be seen that, since the quantity of water required by the cement is known, it only remains to find out how much is required by the sand, in order that it may have the surface of each grain covered by a thin film of water. In other words, the sand needs damping, so that it may not take the water for this purpose from the Portland cement.

The quantity of water required to damp the sand can be ascertained easily in the following manner:—Weigh out half a pound of dry standard sand; immerse it in clean water in a small bowl; stir it well and allow it to stand. Then pour off the superfluous water and empty the sand on to a clean cloth and wring out the cloth with the sand in it. Screw the cloth up by the four corners and whirl it at arm's length until only occasional drops are thrown off. Pour the sand on to a sheet of plate glass; then with a small trowel push the sand to one side of the glass. Mop up the water on the glass, push back the sand with the trowel and repeat the process to and fro, mopping the glass each time, whilst keeping the sand well mixed, until no pools of water remain on the glass and the glass is only just uniformly damp. Weigh out a convenient quantity of the sand, dry it thoroughly and weigh it again; the difference of weight will be that required to damp the known weight of dry sand. The percentage weight can then be calculated. Suppose that it is 4 per cent. of the weight of the dry sand. The total weight of water to produce the standard consistency may then be calculated as follows:—

1 pound of Portland cement @ 22% = ·22 pounds of water.
3 pounds of standard sand @ 4% = ·120 ,, ,,
— ——
4 pounds of dry materials require . . ·340 ,, ,,

*i.e.*, the dry materials require ·340/4 of 100 = 8·5 per cent. of water to produce a standard consistency.

This may be reduced to a rational formula and thereby the necessity for doing a physical test to obtain the consistency of the cement mortar may be avoided.

Let $C$ = the number of parts by weight of dry Portland cement.
$S$ = the number of parts by weight of dry sand.
$c$ = the percentage of water by weight required by the Portland cement.
$s$ = the percentage of water by weight required by the sand.
$w$ = the percentage of water by weight required by the combined weights of Portland cement and sand.

Then

$$w=\frac{Cc+Ss}{C+S} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If, as in the example given for the British Standard Specification Test, $C=1$ and $S=3$, then

$$w=\frac{c+3s}{4} \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

The sand specified for this test is graded within the narrow limits of the 20 × 20 and 30 × 30 square mesh sieves whose apertures are respectively 0·034 in. and 0·023 in., consequently the sizes of the grains are not very different. It should therefore be the easier to establish definitely the quantity of water which is sufficient to damp a given weight of this sand. If this is 4 per cent. of the weight of the sand, then formula (2) will be further simplified and become

$$w=\frac{c}{4}+3 \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

If extreme accuracy is required in a test it may be necessary to add a small weight of water for the loss due to evaporation and the damping of the tools, etc., used in gauging up the mortar for the briquettes, but this would be so small that for practical purposes the rounding off of the percentages obtained for the Portland cement and sand would cover these losses. If this were, however, desired, then formula (1) would become

$$w=\frac{Cc+Ss}{C+S}+e \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

where $e$ = moisture lost by evaporation and left on tools, etc.

In the case of a sand containing grains of many different sizes, such as washed Thames sand out of ballast, and which may have been graded, and for which the percentage moisture required to damp each grade has been determined, it is easy to estimate the total moisture needed in order to damp a mixture in any proportions of those grades.

Let $S\ S'\ S''$ be the number of parts by weight of the different grades of sand, and
$s\ s'\ s''$ be the corresponding percentages of water required respectively to damp those grades.

Then
$$w=\frac{Ss+S's'+S''s''\ .\ .\ .}{S+S'+S''\ .\ .\ .} \qquad . \quad . \quad . \quad . \quad . \qquad (5)$$

where $w$ = the percentage by weight of water required by the total weight of sand.

## CONSISTENCY OF CONCRETE.

In order to obtain the standard consistency for any proportions of concrete composed of Portland cement, sand and coarse material, the same principle may be adopted as in the case of mortar. The quantity of water required to damp the stone may be obtained experimentally in exactly the same way as that described already for sand.

If in addition to the notation in formula (1)

$G$ = the number of parts by weight of gravel or coarse material, and
$g$ = the percentage of water by weight required to damp the gravel,

Then formula (1) for concrete will be

$$w=\frac{Cc+Ss+Gg}{C+S+G} \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

This formula (6) may be worked out and shewn in tabular form as given in Table I. where the proportions of the concrete are 1 : 2 : 2 by weight. This method has the advantage that it gives a clear explanation of all the essential details required to work out the formula, and at the same time is arranged in a convenient way for checking the calculations and for recording the particulars of the materials and quantities used.

TABLE I.

| Materials. | Weight (dry). | | Water. | |
|---|---|---|---|---|
| | Proportion. | Pounds. | Percentage. | Weight in Pounds. |
| Col. 1. | 2 | 3 | 4 | 5 |
| (*C*) Portland Cement .. .. | 1 | 1 | 22 | ·220 |
| (*S*) Thames Sand .. .. .. | 2 | 2 | 6 | ·120 |
| (*G*) Gravel .. .. .. .. | 2 | 2 | 1·75 | ·035 |
| Total .. .. .. .. | — | 5 | — | ·375 |
| Average .. .. .. | — | — | 7·50 | — |

NOTE.—For the sake of simplicity the weights are given in pounds and decimals of a pound, though doubtless for laboratory work cubic centimetres and grammes may be considered more convenient.

The determination of the quantity of water required to moisten the surfaces of the small stones can be arrived at more rapidly than in the case of sand. In fact, after the gravel has stood in water, then been swung at arm's length in a cloth, and tipped on to the glass plate, it may not require to be moved about on the plate glass surface. It is soon apparent if it has been uniformly damped by the amount of moisture left on the glass after the gravel has been moved once. In the case of an impervious material like flint it is clear that only the surfaces are damped. But these surfaces in many rounded impervious pebbles are often irregular, and consequently the wetted surfaces are much greater than might be expected from even a globular pebble. In addition to this relatively large surface which requires moistening there are the cases of materials which absorb water to a greater or less degree. Undoubtedly the safest way is to include this absorbed quantity in the total required. If this were not done there would be cases in practice where some of the pebbles would absorb water and thereby take what was required to moisten the surfaces of some of the other pebbles. It is also the case that in certain instances it would be advantageous to the mortar surrounding the pebbles to be in contact with pebbles containing an additional quantity of water, which would tend to keep the mortar damp while it was thoroughly setting, and which at the same time would not affect its consistency.

When the proportions (as is usual on works) are by volume, the weight per unit volume of the materials must be determined experimentally. It is well known by those who have had experience on works that a cement gauge box may be filled with cement to contain quantities of Portland cement varying from 70 lb./cu. ft. to 90 lb./cu. ft. The gauge box for sand may also contain various weights of sand depending on the way in which it was filled and whether the sand was dry or damp. The same remark applies to a less extent in the filling of a banker for gravel or granite. All these are points which are of considerable importance, but they do not invalidate the methods described for ascertaining the standard consistency, because the method adopted is taken on a percentage basis of the *weight* of the material.

A given weight of dry material of any one grade contains only a certain number of grains or pebbles and consequently a certain surface area. This is important as it does not limit the application of the principles already described.

An example is given in the following table, in which the proportions are 1 : 2 : 1 by volume :—

TABLE III.

| Material. | Proportions by Volume. | Weight per cu. ft. | Weight (dry) | | Water. | |
|---|---|---|---|---|---|---|
| | | | Proportions. | Pounds. | Percentage. | Weight in Pounds. |
| Col. 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (*C*) Portland cement .. | 1 | 90 | 1 | 1 | 22 | ·220 |
| (*S*) Thames sand .. | 2 | 110 | 2·44 | 2·44 | 6 | ·146 |
| (*G*) Gravel .. .. | 1 | 96 | 1·07 | 1·07 | 1·75 | ·019 |
| Total or average .. .. .. .. .. .. | | | | 4·51 | 8·54 | ·385 |
| Extra water .. .. .. .. .. .. .. | | | | | 10 | ·039 |
| Total water for a plus 10 per cent. consistency .. | | | | | .. .. | ·424 |

NOTE.—If the percentage of water had been taken on the gross weight of the materials used it would have been 9·40 per cent.

### CONCLUSION.

In this paper an attempt has been made to eliminate differences in mortars and cements due to differences of consistency. In fact a method has been described for determining a standard consistency, and also for describing, on a rational basis, one which is greater or less than the standard consistency.

So that briefly a means is afforded by the use of these rational formulæ to compare :

(1) The relative strengths of mortars and concretes made up in various proportions of the same materials.

(2) The relative strength of mortars and concretes made up with the same cement, but with different aggregates in any desired proportions.

### DISCUSSION.

**Mr. E. F. Etchells, F.Phys.Soc.**, in opening the discussion, said that there was one feature with regard to the variations in the testing of cement upon which Dr. Owens would probably speak, and that was the effect of slight variations in the surface of the block in altering the result of the tested specimen With regard to the equations in the paper there seemed to have been a certain hesitancy whether to deal with weight or percentages. He agreed with the author when he said that weight rather than volume was a more dependable measure of quantity, and he also agreed that in arriving at the truth it was necessary to eliminate all the variables.

**Dr. J. S. Owens, F.G.S.**, thought the paper was an extremely suggestive one even though some of them might differ from the conclusions arrived at in it. With regard to the shape and nature of the surface of the block, the Institute had been carrying out tests for some time, and a curious variation had been noticed which was unaccounted for in the crushing strength of some of the blocks On examination, the fact was detected that the surfaces between the pattern of the machine, against which the pressure came, were not flat. It was then attempted by measuring the departure from flatness to relate the breaking strength of the block to the nature of the surface. It was found that a rough approximation could be obtained. A block which was concave on the surface would break at a lower load than a block with a flat surface or a slightly convex surface, notwithstanding the departure from flatness did not exceed 4/100 in. Thus a block with a valley in the middle of it would go at 14 tons, whereas a flat surface would not go except under 20 to 23 tons. This was a very important point and should be kept clearly in mind. The author had used the term consistency in the paper, but he had not defined it very clearly, and the question was whether the standard consistency as defined in the paper was the consistency required in general practice. The author also stated that each ingredient should have its requisite amount of water. He agreed, but what was the requisite amount of water ? There were several other factors which must be taken into account, as well as the ones mentioned in the paper. Evaporation was important in hot climates especially. If a standard concrete was made up in this country it would probably be found that in a hot climate the amount of water was inadequate because it would have evaporated. Then there was the question of the porosity of the aggregate. If the aggregate was not completely saturated, it would go on absorbing water from the cement and reduce the amount below that required for its setting. There was another thing in connection with the question of the amount of water upon which he did not think sufficient stress was laid, and that was the possibility of adding the requisite amount of water for the separate ingredients individually. He did not think a good aggregate would be obtained by drying it as suggested in the paper. The aggregate must be damp before cement was mixed with it, otherwise a perfect mixture would not be obtained. It struck him that the method proposed in the paper of damping the sand and whirling it round and rubbing it on a glass was only approximately correct. Coarse sand would not hold the water in the same way that fine sand did. The capacity of sand to hold water depended to some extent upon its surface tension, and there was a greater difficulty in getting water away from fine sand than from coarse.

**Mr. H. K. G. Bamber, J.P., F.C.S.,** said it was particularly important to notice that it was becoming apparent to the profession that the amount of water to be added to cement and concrete should be accurately gauged. Nobody knew more than those in the cement industry how many failures in concrete were due to that cause. Either too much or too little water was added, as a general rule. He was not, however, altogether in accord with the author's conclusions, and he was sorry the paper had not taken materials of a more absorbent nature, because he was not at all sure that if that had been done the factors given in the paper would have applied. It was necessary to consider, as Dr. Owens had pointed out, the climatic conditions in this country in determining how much water should be added, and in our circumstances it might easily be found that the factor fixed in the morning would have altered by the afternoon. After all, the result of the work was very much dependent on the experience of the man in charge, who would have to judge accurately whether the amount added was correct or not. Nevertheless, the figures given as the result of the author's test were practically those obtained in everyday use in practice.

**Mr. D. B. Butler,** whilst thanking the author for the painstaking manner in which he had reduced the present rule-of-thumb methods to a scientific basis, asked if he was quite sure of the axioms he had laid down. For instance, on the first page it stated that "It is a thoroughly well-established fact that every Portland cement requires a definite quantity of water in order that it may set perfectly," and later on the author said that the limits were generally between 18 and 25 per cent. in the United Kingdom. He thought the definition was a bit wrong. Did the author mean set perfectly or flux perfectly? The actual amount of water required for setting a cement was much less than that mentioned. Due to the crystallisation of water, the actual amount required for setting had been shown to be 10 per cent. as the result of the analysis of blocks after several months in use, but it was possible to flux a cement with as little water as 8 per cent. The general practice was to use the proper amount of water not to set properly but to flux properly, so that when it was in position the excess water was known. For these reasons he did not think the author's definition was quite the accurate one. What the author did in the paper was really to give a standard method for making test pieces, which was quite different from the setting of cements. With regard to the method of determining the water in a 3–1 mortar, the British standard specification did not give any hard and fast rule for determining the water used for sand briquettes, but other specifications did. For instance, the U.S.A. specification and also the Argentine Government specification gave a formula from which the amount of water to be used for gauging a 3–1 mortar was based on the amount required for the neat cement, following on Mr. Lloyd's method. The method put forward in the paper, whilst giving results similar to those hitherto found in practice, was more applicable to the laboratory than to practical work; it would be extremely valuable for research work and it certainly would enable operators in different parts of the country to get comparative results which he was sure would be a great asset.

**Lieut.-Col. R. de Villamil, R.E.,** said he had done a certain amount of concrete work in buildings in which he wished to keep out the damp, and he had always insisted that the concrete should not be too close and that it should be rather porous, to make it resemble bricks as near as possible. Buildings made with such concrete were extremely dry, and there was no reason why they should be damp. He did not know whether it was possible to improve the concrete by mixing certain materials with the water. When he was in Jamaica he did some concrete work, and it was such a dry place that there was no need to be afraid of the water. He had always been instructed, when making concrete, to wash the sand thoroughly, and on no account to use sea-water. When he went to Port Royal, he had to use concrete for making a battery with walls 10 ft. thick, and he noticed that the contractor made some magnificent concrete. He found that the shingle used was taken out of the sea and used as it was without any washing. Port Royal was built on a spit of sand jutting out in front of Kingston Harbour, and as there was no tide there the water was a little brackish. This gravel mixed with the cement made the most magnificent concrete he had ever seen, and he was wondering whether the brackish water had anything to do with it.

**Mr. A. E. Bell** said that his experience with reinforced concrete had for the most part been of a practical nature; but for the past five years he had been testing cement and concrete in the laboratory, and he welcomed the efforts of the author of the paper to eliminate the personal equation. Having regard to the manner in which our climate varied from day to day and even during the same day, he thought it was safer to specify the consistency after it had been mixed and leave it to the man in charge of the work to see that the right consistency for the particular conditions was obtained, rather than to specify a certain amount of water which would entail drying all the material beforehand if it happened to be wet. One important factor which must be considered now in regard to concrete was labour, and it had occurred to him whether it would not be more economical to add more cement and reduce the labour in the mixing. At present a large amount of labour was used in the mixing and supervision, but with the present cost of labour and cement it would be cheaper to have more cement with consequent less need for such thorough mixing.

**Mr. E. S. Andrews, B.Sc.,** said he did not like the reference to the standard consistency in the paper, because it implied that the consistency given by the methods set out in the paper were the standard in the sense that it was the desirable one. Mr. Butler had pointed out some of the weaknesses of determining consistency by any such means as the formulæ given in the paper, and they ought to keep very clearly before them that the figures of 22 per cent. and the 8½ per cent. were figures used to compare different qualities of cement. It did not follow that 22 per cent. was the correct amount of water to mix with cement in order to get the best strength. They ought also to bear in mind the fact that in testing cement the specimens were kept under water so that the cement could, if it wished, absorb more water than was mixed with it. He did not profess to be an authority on the chemical side of the question of the setting of cements, but it seemed to him a matter of very great complexity, and it seemed that the cement continued to absorb water for quite a long period after it had set, as it was commonly understood. In reading the paper, he had hoped that it would give some information with regard to the consistency which it was desirable to have in a briquette. That was a matter upon which there seemed to be considerable difference of opinion and upon which it would be well to have a very thorough discussion. He understood that in America they were in the habit of mixing their concrete to a considerably wetter mixture than we did in this country, and he would very much like to know whether they got better or worse results from that procedure. He did not like the doctrine laid down by Mr. Bamber, that we must leave the consistency to the man who could tell, by experience, when it was the right one. Whilst appreciating the tremendous value of such experience, we must get down to definite scientific facts and eliminate the personal equation as much as possible.

**Mr. W. J. H. Leverton** mentioned that the author measured the aggregate and sand by weight as well as the cement, but he thought it was the usual custom to specify the cement by weight and the aggregate and sand by measure. He did not know whether it was the latest standard scheme to do as the author had done. He would like to know if the author had worked out figures for using broken brick, which was very much more absorbent than gravel.

**Mr. M. E. Yeatman** suggested that the reason for mixing concrete in America wetter than we did was because of the drier climate.

**The President** in putting a vote of thanks to the meeting, mentioned that Dr. Owens had not referred to the question of the inter-logged air in the sand and gravel, which must be considered. With regard to Col. Villamil's remarks, he would like more information as to the making of a porous concrete which would give that breathing quality possessed by bricks and considered so valuable in house building.

### THE LECTURER'S REPLY.

**Mr. Lloyd,** replying to the discussion, said the question of testing blocks mentioned by Dr. Owens was not exactly relevant to the paper, but it was an extremely important point. If these blocks were tested on their sides, some of the difficulties in regard to the exactness of the dimensions might disappear and more uniform results would be obtained. It was extremely difficult in mixing cubes to get the top surface exactly level, and if there was a protruding lump or stone, it seemed to decrease the strength more than would at first appear. He hoped that the new term he had been charged with having coined would be acceptable. The difficulty was that he had to start from some point; and although it was very difficult to explain consistency, he had taken the method adopted by the British Engineering Standards Association for determining what was considered to be the correct amount of water to add to the cement in order that it should set, as the specification said, properly. The standard specification spoke definitely about the setting time of cement, and that setting time depended upon the amount of water being at or very near to the percentage referred to by one of the speakers as the fluxing percentage. He hoped that would clear up one or two matters raised in this connection. With regard to evaporation, he agreed with Dr. Owens that it was necessary to allow for this. At the same time, having had practical experience on a number of large jobs, in addition to laboratory work, he believed that there were many cases in which evaporation did not enter very largely into the matter because the concrete was not exposed. For instance, in tunnel work and large underground work the material was really kept in an ideal condition for producing good concrete. Again, he was sure that Dr. Owens and other speakers had misunderstood him as regards the drying of the materials. He did not for a moment suggest that materials should be dried except for experimental purposes and for finding out the amount of moisture in the materials as they were delivered to the job. When the amount was known in this way it was only necessary to add the additional amount in order to arrive at the consistency desired for the particular class of work. With regard to surface tension, his experience completely bore out what Dr. Owens said. Nevertheless, he had been able to reproduce his results with very great accuracy. He was not altogether with Mr. Bamber as to the possibility of a different factor being necessary in the afternoon from that found best in the morning, owing to the vagaries of this climate. His experience of large work had shown that sand delivered damp and dried on the surface still retained its dampness in the centre of the mass, whilst, on the other hand, sand which had been damped on the surface by rain was not wetted for more than a very small thickness. The underneath in these circumstances was very much the same after the shower as before. He agreed that in some small jobs there might be difficulties in the manner suggested. The question of fluxing had been criticised by Mr. Butler, but he wished again to point out that he used the term setting in the sense it was used in the British standard specification. He had hesitated to refer to the formula in the standard specification because he felt there must be some mistake in it, as he could not work out the result as stated there. In reply to Mr. Bell, he again stated that he did not intend that all the materials on a job should be dried. That would be impracticable. He thought Mr. Andrews had misunderstood the paper when he spoke of 22 per cent. as the definite amount of water for the cement consistency and 8½ per cent. for the sand consistency in a 2–1 sand concrete. He did not mean that. What he meant was that he took the examples in the paper and pointed out that between 18 and 25 per cent. would be the amount of water required and that usually the amount of water required for the sand would be one-quarter that required for the cement He was pleased to hear that he had arrived at figures which were usually those employed in practice He agreed that it was noticeable that some cement did appear to continue to absorb water after it was set, and often the interior of the block was perfectly dry, although it had been in water for 28 days or even a year, whilst the outside was wet. The question raised by Mr. Andrews as to the most desirable consistency was a very important one and it was at the root of the whole design of practically every job, because it was necessary to have a certain consistency for certain particular parts of a job. In the case of a lining of a tunnel, he had known a minus consistency of 10 to 15 per cent. to be the most suitable—*i.e.*, in order to get the concrete to stick to the invert of the cast-iron tunnel it had to be put in a great deal drier than was usually the practice on account of the sloping curve of the tunnel. The same thing had to be done on the crown and the sides of the walls of the tunnel; but in the case of the bolts of the sections of cast iron forming the tunnel, a plus consistency of 23 per cent. was required in order that the bolt heads should be completely covered. It seemed to him that the nature of the job settled the consistency that was required. One speaker had referred to the proportion of sand and aggregate being by weight. He did not intend that they should be taken by weight. His experience was that it was usual to take the three constituents, sand, cement and aggregate, by volume. At the same time, in certain cases it would be most desirable to be able to say that there was a certain amount of cement. In Table 3 he had tried to co-ordinate volume and weight, and in this particular case he had put the sand in a box 1 ft. cube and got 96 lb. per cu. ft He did the same with the gravel and the sand.

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# THE MANIFOLD USES OF CONCRETE.

### By T. J. CLARK.

At the Concrete Institute on Friday, April 9th, Mr. T. J. Clark gave a lecture on "The Manifold Uses of Concrete." This, it will be remembered, was one of a series of three public lectures organised by the Institute as an experiment. The aim of the lecture, which was illustrated throughout by lantern slides, was to bring home to the minds of the audience the enormous strides made in concrete practice during recent years, since nothing, perhaps, in constructional methods is more striking than the large and ever-increasing variety of uses to which this material is now being applied not only as a substitute for timber, bricks, iron and steel but as a constructional material in itself the value and the scope of which are now beginning to be realised.

The first section of the lecture was devoted to "Concrete in the Home," the prime requisite of the home being a house to live in. The shortage of houses was touched upon, and stress was laid upon the opinion that a vital factor in the future prosperity of the nation is the prosperity of the worker, which could only be secured by an improvement in the conditions of life; and chief among these is the character of the house in which he dwells. The essentials of a thoroughly satisfactory home were that it should be conducive to health, provide comfort, afford pleasure and be within the means of the family who occupied it. The qualities of concrete were then examined with a view to showing the extent to which this material fulfilled the required conditions.

The artistic possibilities of concrete, which were very great, must not be lost sight of. Many gloomy predictions had been made as to the perpetuation of ugliness which would result from the wide adoption of concrete for building purposes. That this danger is not now to be feared was demonstrated by a considerable number of pictures thrown on the screen in which were seen concrete houses of many types, and artistically designed and grouped. The beauty of the design was limited only by the ability of the designer—and the man who would produce a bad design in concrete would produce a bad design in any other material—while there were so many forms of surface treatment available that any house might be rendered harmonious with its surroundings and in conformity with local traditions.

It was surprising to find in how many ways concrete could be used in and about the home. In the house itself were sinks, flushing tanks, supply tanks, kerbs, window-boxes and many more; in the garden, to mention a few, were paths, edging tiles, kerbing blocks, steps, walls, garden frames, garden seats, pergolas, balustrades and vases.

The lecturer then passed on to the increasing use of concrete on the farm, and pointed out that, by the adoption of modern methods, the farm produce was improved in quality and increased in quantity. A *sine qua non* of successful farming was sound, healthy farm buildings. Animals, like human beings, could not be expected to thrive in damp or dirty surroundings, and it was the duty of the farmer to provide wholesome accommodation for his stock. Many farm buildings were being erected in concrete, which was found eminently suitable for the purpose. These included cow-houses, dairies, stables, barns, sheds, silos, poultry-houses and pigsties, while other uses of concrete mentioned in this connection were fences, floors, troughs, tanks and manure-pits.

The question of ensilage had not, it was thought, received sufficient attention in this country, since this method of the preservation of fodder had so many points in its favour; in America and Canada the use of the silo was one of the most marked features of modern farming methods, and the concrete silo was rapidly rising in favour.

The subject of concrete roads was examined at some length, and many photographs of such roads both in this country and America were thrown on the screen. In America and Canada this form of construction had been taken up with great enthusiasm, and in those countries alone 15,851 miles of concrete road had been laid during the ten years ended December 31st last. During the present year over 7,000 miles were contemplated. In our own country progress had been slow, but the conditions were different. Even here, however, the difficulties were being surmounted and the concrete road was making headway.

Municipal and other public authorities were resorting to the use of concrete for sewer pipes, water-mains, poles of many kinds, kerbs, and channels and manholes, while the uses of concrete on the railway were numerous and interesting.

In conclusion, Mr. Clark said that wide as was the field which concrete already covered, in his judgment it would be far wider yet. It had proved most conclusively its own intrinsic worth, and the experience of its value had resulted in a wider appreciation of the great possibilities which lay before it, and would unquestionably lead to still further extensions of its use and its application in new directions for purposes hitherto untried.

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## MEMORANDUM.

**Concrete Institute.**—The Annual General Meeting of the Concrete Institute was held on Thursday, May 27th, at Denison House, Vauxhall Bridge Road, S.W., when Mr. E. Fiander Etchells, the new President, took the chair. The annual report of the Council for the past session was presented, and the Medal of the Institute for the best Paper in the session 1918–19 was presented to Dr. Boswell.

Mr. Etchells proposed a vote of thanks to the retiring President, Mr. H. D. Searles Wood, and referred to the great interest he had taken in the work of the Institute.

It was announced that an invitation had been received from the Société des Ingénieurs Civils de France to join the members of that Society in a visit to the devastated regions of France on June 23rd, 24th and 25th, and members were asked to notify the Secretary as soon as possible of their intention to join the party.

Major Halstead Best, R.E., then read a Paper describing the work of constructing the Richborough Port, a discussion followed, among the speakers being Mr. F. E. Wentworth Sheilds, Mr. H. J. Deane, Major Shelbourne and Lieut.-Col. Lewis.

Further reference to this meeting will be made in our July issue.

# "CONCRETE SHIPBUILDING"

## REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

**By ALFRED B. SEARLE.**

## CHAPTER XII.

### RELATIVE COSTS OF CONCRETE VESSELS.

The cost of any vessel should be considered with regard to (i.) the cost of construction and delivery to the purchaser, and (ii.) the cost of maintaining and repairing her during a period of ten years or more. It is obvious that a method of construction which was low in first cost but very extravagant with regard to repairs would be unprofitable and might be further undesirable owing to the involved risks of life to the crew.

With regard to the cost of building reinforced concrete ships, very little information is available. On the whole, it may be said that they can be built at a less cost per ton of deadweight carried than steel vessels, and this in spite of the fact that they have to be of bigger dimensions to carry the same dead weight. There is a distinct advantage in building a large number of similar ships since the shuttering can be used several times. This shuttering is expensive, and if its cost has to be borne by a small number of vessels their price will be correspondingly greater.

In the issue of *Marine Engineering* for July, 1917, the following table of comparisons appeared :—

TABLE VII.

| | Reinforced Concrete | Wood | Steel |
|---|---|---|---|
| Estimated life .. .. .. .. | 35 | 15 | 25 |
| Displacement (light), tons .. .. | 259 | 135 | 151 |
| Pounds per cubic foot capacity .. | 19·25 | 10 | 11·2 |
| Cost per cubic foot .. .. .. | ·318 | ·304 | ·687 |
| First cost .. .. .. | $8,547 | $8,171 | $18,466 |
| Total cost of repairs .. .. | 855 | 2,432 | 1,847 |
| Interest on first cost at 5 per cent. | 15,000 | 6,128 | 23,082 |
| Interest on repair cost at 5 per cent. | 750 | 912 | 1,154 |
| Total cost .. .. .. .. | $25,152 | $17,643 | $44,549 |
| Total annual cost .. .. .. | $718·63 | $1,176·20 | $1,781·96 |

The American Joint Committee has reported that for a vessel of the type recommended by them, and 227 ft. by 42 ft. by 23 ft., and 3,675 tons displacement at 18 ft. draught, assuming sand, stone, cement, and reinforcing steel at prices current in 1918, the cost of the hull (exclusive of any equipment such as deck houses, spars, anchors and chains, engines, boilers, and tanks) would approximate £24,600. Assuming the construction of ways which could be used for the construction of five or more ships, the cost per ship would approximate £1,600, making a total cost of the hull (exclusive of equipment) £26,200.

Based on the figures noted above, the cost of the hull per ton of dead weight would approximate £13. Owing to a wide range in costs of steel and wooden ships of the same character, it is somewhat difficult to arrive at anything approaching a definite estimate for steel or wooden ships. The best figures available seem to indicate that the cost of steel hull per dead-weight ton ranges from £18 to £25, while the cost of a wooden hull ranges from £14 to £21.

Estimates of cost by the American Shipping Board for concrete vessels of 3,000-7,500 tons dead-weight capacity, including equipment, are between £20 and £25 per ton for concrete ship dead-weight carrying capacity, as against £35 for wooden ships and £37 to £46 for steel ships.

W. Pollock, at a meeting of the Institute of Naval Architects, March, 1918, stated that " the prime cost of the finished reinforced concrete work for an ordinary vessel with shipshaped lines at the present time should average £8 15s. per ton, made up with the double shuttering at 18s. per square yard for timber, and 6s. 6d. for labour—the concrete at 1s. 8d. per cubic foot, and the round steel bars from £16 10s. per ton for the large diameter to £22 10s. per ton for the small diameters. Vessels with straight lines will cost less, and probably a saving of £1 to £1 5s. per ton will be made, the usual establishment charges and profit being added. These figures are based on a 300-ton dead-weight coaster and for the first vessel only ; larger vessels would, of course, show a reduction.

Assuming that the shuttering will last for five vessels of the same design, the cost of the wood could be divided over that number, but would require an addition of 10 per cent. of wood in each case to cover depreciation and damage. If the wood were coated, the straight shuttering might last for eight vessels and the curved for six. The cost of removal and re-erection for the second and subsequent vessels might be taken at, say, 9s. per square yard for double shuttering on each occasion.

The cost of fenders, woodwork generally, fittings and equipment, will be the same as for a steel or wooden vessel of the same size, but, owing to the larger dimensions, will be about 8 per cent. greater for a vessel of the same dead weight.

A considerable reduction is obtainable in the labour because angle-smiths, platers, and riveters are practically dispensed with.

The fact that a concrete hull weighs twice as much as one of steel has a serious effect on the ratio of dead-weight capacity to displacement, and it is impossible to predict the extent to which this will restrict the application of reinforced concrete to the construction of cargo carriers.

(*To be concluded.*)

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## MEMORANDUM.

**Machine-Surfaced Flooring.**—In finishing the large concrete floor areas of the new buildings for the Massachusetts Institute of Technology, electrically operated carborundum grinding machines were employed with interesting results. After the flooring had been constructed in the ordinary manner, the upper surface, purposely left rough, was covered by a 2-in. layer of concrete composed of one part of cement and six parts of marble chips, no sand being used. This fine concrete was screeded level and allowed to set for about seven days, after which the surface was ground by one of the carborundum machines. During the process of grinding the floors were kept wet, and it is stated that one man was able to finish 1,000 sq. ft. daily. Flooring treated in this manner gives an appearance of smoothness.

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

**By OSCAR FABER, O.B.E., D.Sc., etc.**

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER III.

### *Beams and Slabs.*

28. It was shown that the great principle underlying the design of reinforced concrete is to find places where tension may occur and strengthen these places by steel rods so disposed as to be capable of resisting such tension.

It was further shown (*Fig.* 1) that a simple beam on two supports develops tension along the bottom.

The reinforcement of such a slab therefore consists essentially of steel rods along the bottom from one support to the other as shown in *Fig.* 4 (*a*).

29. These may take the form of round rods with their ends bent up as shown, or may consist of expanded metal or some form of woven mesh. Round rods are, however, generally cheaper and more satisfactory even when the cost of bending and fixing has been fully taken into account.

30. In addition to the *main reinforcement* some rods in the other direction are very desirable (see crossbars, *Fig* 4*a*). The object of these is chiefly as follows: When concrete sets and dries, it contracts in all directions. Therefore a floor slab resting on the walls of a building which resist contraction tends to produce cracks, and if reinforced in one direction only, cracks badly in that direction owing to the absence of tensile strength at right angles.

31. The rods should be kept up a little distance from the bottom, otherwise they rust and in time corrode away and destroy the ceiling, and the slab itself. The usual cover is ½-in. slabs, or the diameter of the rods, whichever is the greater. The cover is best obtained by laying the rods on wooden slats of the required thickness, about 4 ft. apart, and withdrawing these gradually as concreting proceeds and the rods have found their place in the concrete.

32. Reinforced slabs carry roughly the following loads per square foot of floor on different spans :—

| Thickness. in. | Own weight. lb. | Live load. lb. | Total load. lb. | Safe span. ft. |
|---|---|---|---|---|
| 6 | 75 | 100 | 175 | 10 |
| 5 | 67½ | 100 | 167½ | 8½ |
| 4 | 50 | 100 | 150 | 7 |

For bigger spans, increase the thickness in proportion to the span.

Thus, for 20 ft. we should require a 12-in. slab, and so on.

For bigger loads, increase the thickness in proportion to the square root of the load. Thus, for 300 lb. a foot on a 7-ft. span, we require

$$\sqrt{\frac{300}{150}} \times 4$$

$$= \sqrt{2} \times 4$$

$$= 1{\cdot}414 \times 4,$$ or roughly a 6-in. slab.

33. The sizes of bars required for different thickness slabs are roughly as follows :—

4-in. slab .. ⅜-in. bars at 6-in. centres.
5-in. slab .. ½-in. bars at 9-in. centres.
6-in. slab .. ½-in. bars at 6-in. centres.

The cross bars may be the same size as the main bars, but four times the distance apart.

34. For other slabs, proportion the main rods as ·675 per cent. of the area of concrete, as follows :—

In calculating this area, the depth is taken from the compressed face to the centre of bar, the cover being neglected, and the width of concrete considered is conveniently one inch.

Then a 12-in. slab, for example, would be 10½ in. deep multiplied by 1 in. wide concrete area = 10½ in.

$$\text{steel area} = \frac{\cdot 675 \times 10\tfrac{1}{2}}{100}$$

$$= \cdot 071 \text{ sq. in.}$$

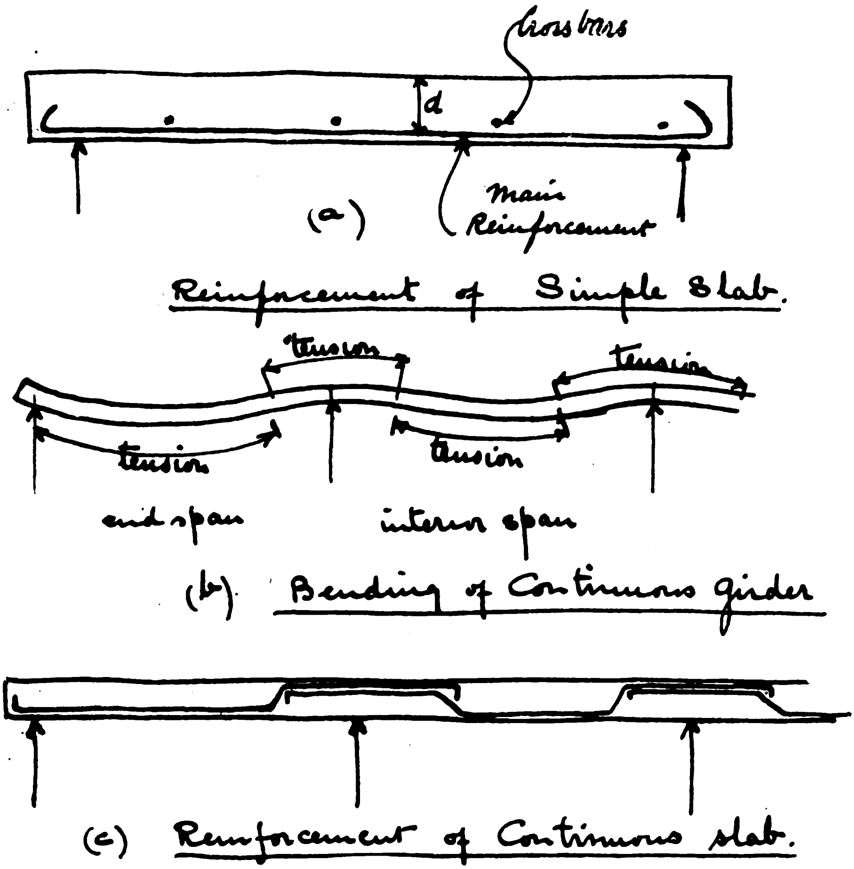

Cross bars
d
Main Reinforcement
(a)
Reinforcement of Simple Slab.
tension
tension
tension
tension
end span
interior span
(b)
Bending of Continuous girder
(c)
Reinforcement of Continuous slab.

Fig. 4. Reinforcement of Slabs.

Now a ¾-in. bar has an area of ·44 sq. in. and therefore needs to be

$$\frac{\cdot 44}{\cdot 071} = 6 \cdot 2, \text{ or, say, 6 in. apart.}$$

35. Coming now to slabs over many supports, these will deflect in the manner shown in *Fig.* 4 (*b*), and referring back to *Fig.* 1 and remembering that the extended portions are in tension, it will be clear that the top and bottom will be in tension alternately, the bottom towards midspan, and the top over the supports.

Carrying out our principle of putting tension bars where tension occurs, it is clear that the tension bars must be alternately at the top and bottom also. This could be done by having separate bars for the top and the bottom, but the top bars would be difficult to keep accurately in place during concreting.

For this and other reasons, it is better to bend the bottom bars into a cranked form, so that they lie near the bottom towards midspan and at the top over the supports, as shown in *Fig.* 4 (*c*).

It is usual to have some bars straight along the bottom in addition to the cranked bars, and often they alternate.

36. Slabs or beams designed in this way over several supports are called *continuous* beams or slabs, and are stronger than simple ones on two supports only, and the safe spans for different thicknesses given in par. 32 may be increased by 20 per cent. for interior spans (continuous both ends) and by 10 per cent. for end spans (continuous one end only).

It will be seen that the interior spans then have the ***thickness in inches half the safe span in feet***, which is a useful rule to remember.

This, of course, only applies for the load given, namely, 100 lb. per ft. of floor, which is good for all ordinary offices and public buildings, but not for warehouses.

37. We must now show how the above results can be arrived at by calculation. Let us consider the simple slab in *Fig.* 4 (*a*) to be stressed till it has the permissible stresses of 600 lb./sq. in. in the concrete at the top, and 16,000 lb./sq. in. in the steel near the bottom.

Now we first must find the position of the neutral axis. In *Fig.* 1 this was shown half-way down the beam, and for beams of one material equally strong in tension and compression, and of a symmetrical section, this is so. With concrete beams, however, it is otherwise, as will be seen from the following.

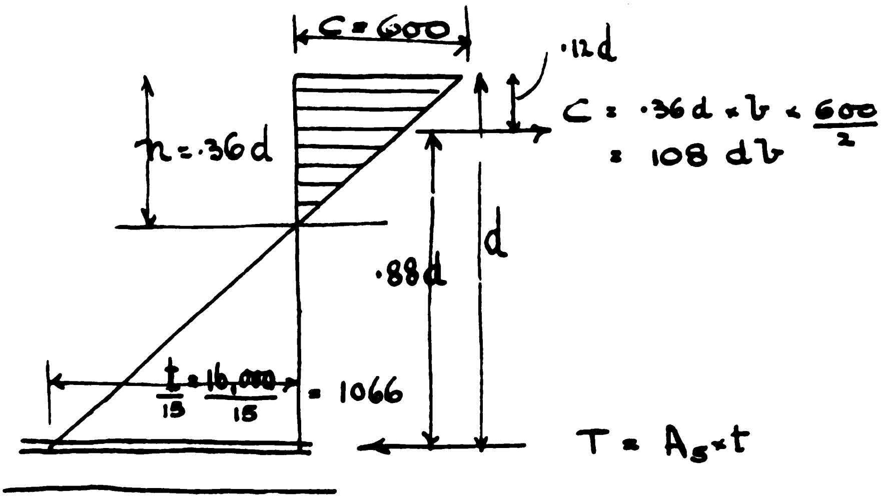


Fig. 5. To illustrate Stresses in Simple Slabs.

The shortening on the top is proportional to 600 to some scale.

Since the steel stretches only $\frac{1}{15}$th times as much as concrete for the same stress (see par. 10), the extension of the steel will be proportional to $\frac{16,000}{15} = 1,066$ on the same scale as that which gave 600 as the shortening on the concrete.

Hence, if to any scale we set along 600 units to one side of a vertical line at the top to represent the shortening of the concrete, and set along 1,066 units to the other side as the steel line to represent the extension of the steel, the oblique line joining these two lines represents the extension or shortening at different distances down in the slab, and where it cuts the vertical basis line gives the position of the neutral axis.

If this be done graphically, it will be found that the depth of the neutral axis is

$$n = \cdot 36d.$$

That is, the neutral axis is approximately one-third down from the compressed face.

38. Now, if the beam breadth is $b$, the area in compression is clearly the area above the neutral axis—

$$= \cdot 36d \times b.$$

The stress on this area varies from zero at the neutral axis to 600 at the top, the average being therefore 300lb./per sq. in.

Hence the total compression force

$$\begin{aligned} C &= \text{area} \times \text{stress.} \\ &= \cdot 36d \times b \times 300. \\ &= 108db \text{ lb.} \end{aligned}$$

Now in any beam, the total tension is equal to the total compression, since otherwise the difference would represent an unbalanced thrust or tension, which clearly cannot exist at the ends of a beam resting on supports with roller bearings as in *Fig.* 1, since such thrust or tension would immediately relieve itself by rolling one bearing out or in from the beam.

Therefore, $108db$ also represents the total tension in the steel.

Now if we write the area of steel as a percentage of the area of concrete, we have

$$A = \text{area of steel} = \frac{pbd}{100}$$

where $p$ is the percentage.

Clearly the total stress on the steel is

$$T = \text{area} \times \text{stress}.$$

$$= \frac{pbd}{100} \times 16{,}000.$$

$$= 160\,pbd.$$

Therefore $C = T$.

$$108\,db = 160\,pbd.$$

$db$ cancels out from both sides, leaving

$$108 = 160p.$$

$$\text{or } p = {\cdot}675.$$

This is the proof of the *economical percentage* referred to in par. 4.

With no other percentage are the stresses of 16,000 in the steel and 600 in the concrete reached simultaneously.

39. Now referring back to *Fig.* 5, the compression $C$ clearly acts at the centre of gravity of the top triangle which represents the stress in the concrete, that is, one-third the distance down, or

$$\frac{n}{3} = \frac{{\cdot}36d}{3} = {\cdot}12d$$

from the top, or a distance

$$d - {\cdot}12d = {\cdot}88d$$

from the steel.

Now the *moment of resistance* of a beam, as we shall see, is the product of the force (tension or compression) into the distance between the two faces (tension and compression).

Denoting this by $R$ (moment of resistance) we have

$$R = \text{force} \times \text{distance}.$$

$$= 108db \times {\cdot}88d.$$

$$= 95bd^2.$$

This is a very important result, as we shall see in what follows.

## MEMORANDUM.

**Reinforcing Bars for Concrete.**—The question of reinforcing bars for concrete was very fully discussed at the Annual Convention of the Railway Engineering Association, U.S.A.

Specific prohibition for twisted bars for the reinforcement of concrete, as provided in the masonry committee's specifications, met with some objection. Hot twisted bars are dangerous, according to T. L. Condron, while Mr. Condron and Prof. A. N. Talbot agreed that cold twisted bars give no advantage over plain or deformed bars commensurate with the extra cost of the twisted bar. A suggestion that the twisting is in itself a test of the good quality of the steel was characterised by Mr. Condron as "salesman's talk." A proposal to limit the prohibition to hot twisted bars was voted down.

Another proposal, by E. A. Frink, to require reinforcing steel to conform to the specifications for structural steel was defeated, the committee pointing out that many engineers prefer the harder steel for reinforcement. The committee was sustained on some other points and its specifications were adopted.

Copper-plated bars, copper-alloy bars and a rough enamel coating for bars were suggested by the committee on electricity for use in reinforcing concrete subject to electrolytic action. This was accepted as information without discussion. It was pointed out that in reinforced concrete ships protection has been based upon density and richness of concrete and high quality of materials and workmanship, while experiments have been made with non-metallic waterproofing paints.—*Engineering News Record.*

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

***In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.***

*Question.—Will you please say how to calculate the increased strength of floor joists when embedded in concrete?*

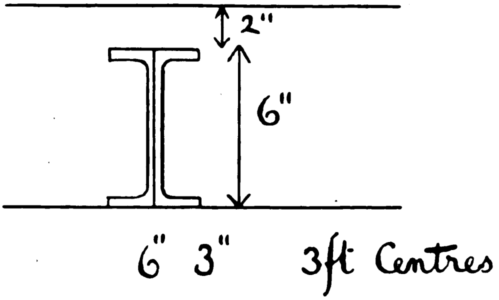
*Answer.*—When the concrete is flush with the joists top and bottom, no increased strength is obtained.

If the top of the concrete is above the top of the joists, the radius arm is increased, and the strength may be taken as the ordinary strength increased in the ratio.

$$\frac{\cdot 88\,D}{d}$$

where $D$ is the distance from the top of concrete to the bottom of joist, and $d$ is the depth of joist.

*Example.*—A floor has 6×3 R.S.J.'s at 3 ft. centres, and has concrete 2 in. above the top, as in sketch. What is the safe load on a 12 ft. span.



*Answer.*—A 6×3 carries 2·8 tons on a 12 ft. span. Hence the safe load of the floor, with joists 3 ft. apart, is

$$\frac{2{\cdot}8\times2{,}240}{12\times3}=175 \text{ lb. per sup. ft.}$$

By the above rule this may be increased by

$$\frac{\cdot 88D}{d}$$

$$=\frac{\cdot 88\times8}{6}$$

$$=\frac{7}{6}$$

So that the safe load will be

$$175\times\frac{7}{6}=205 \text{ lb. per sup. ft.}$$

*Note.*—The above increase is only justified when the percentage of steel in one flange does not exceed ·675 per cent. of the area of concrete between joists.

In the above case, the area of one flange is ·348×3= 1·05 sq. in.

The area of concrete is 8 in.×36 in.= 288 sq. in., so that the percentage is

$$\frac{1{\cdot}05\times100}{288}=\cdot365$$

and the increase is justified.

## MEMORANDUM.

On May 14th a party of students of the College of Municipal and Sanitary Engineers, accompanied by their instructor, Mr. G. Trotman, paid a visit, by invitation, to the Permanent Collection of Concrete Products at 143, Grosvenor Road, S.W.1, which has been arranged by the Concrete Utilities Bureau, of 35, Great St. Helen's, London, E.C.3. The party was conducted over the exhibition by Mr. T. J. Clark, the Bureau Manager, who, after explaining that the collection had been assembled with an entirely educational object, described the construction and the uses of the various articles on view. The visitors were keenly interested in all they saw, and expressed their high appreciation of the opportunity thus afforded them of adding to their knowledge of the numerous applications of concrete.

# NEW BOOKS

## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

### "Mathematics for Engineers." Part II. By W. N. Rose.

Chapman and Hall. 13s. 6d. net.

The author evidently has a practical bent of mind, and is able to illustrate his mathematics with constant reference to examples in engineering which serve alike to keep the student interested and help him to realise that these matters really have some practical interest—which under the old system of teaching mathematics he was likely to forget—and also help him to keep a clearer picture of the subject in his mind. In this respect the author follows Messss. Usherwood and Trimble's excellent *Practical Mathematics*, which we know to have rendered yeoman service. The present volume leads gently up to the calculus and its applications, as far as simple differential equations, and contains chapters on polar co-ordinates, harmonic analysis, solution of spherical triangles, probability and theorem of least squares.

Besides containing many worked-out examples, exercises are given after each chapter for the student to sharpen his tools on, with answers at the end of the book. Four-figure mathematical tables are included.

The book should undoubtedly be useful to engineering students. O.F.

### "Foundations for Machinery." By Henry Adams, M.Inst.C.E. M.I.Mech.E.

Technical Publishing Co., Ltd. 3s. net.

The need of a small volume giving the essentials of the subject of foundations for machinery has long been realised by designers of industrial buildings, and this want is admirably fulfilled by this publication.

Although at first glance the formulæ therein contained may terrify the average busy man, the lucidity with which every example is marked out makes the information given intelligible to even a small builder or foreman who may be called in to put down the concrete bed for a new engine or machine.

Much useful data relative to soils, subsoils and safe loads on various materials is included and the suggestions as to pier and arch construction in "doubtful" soils is applicable to under issues than those dealt with in this volume.

Especially interesting are the two chapters on vibration and its causes, and we would suggest that in a future edition more space should be given to this important subject. We would also suggest that fuller details of bolts, nuts, locknuts, etc., should be included in any future edition.

The illustrations, which are numerous, are models of their kind and we can confidently recommend this volume to all interested in the erection and equipment of buildings in which power of any kind is employed.

### Stresses in Structural Steel Angles. By L. A. Waterbury, C.E.

London: Chapman & Hall, Ltd. 77 pp. + v. Price 5/6 net.

*Contents.*—Relation between Bending Moment and Flexural Stress—Expressions for the Section Modulus—Product of Inertia—Section Modulus Polygons—Neutral Axes—Plane of Loading—Combined Stresses—Flexure for Angles in Pairs—Transfer of Stress by Shear to an Outstanding Leg—Efficiency of End Connections—Tables.

As will be seen by the table of contents, the author has considered all the important factors affecting the stresses in steel angles, and he has computed the values of the products of inertia for commercial angles 2 in. by 2 in. and larger, and published them in convenient table form at the end of the volume. The values for this element are not given in the ordinary structural handbook, and the present tables are therefore very useful. The section modulus polygon, which is a very useful device for studying and for determining the flexural stresses in unsymmetrical sections, is explained in a very clear manner, and the whole treatise can be recommended as a very good one.

### New Standard Building Prices. By Lieut.-Col. T. E Coleman.

London: E. & F. N. Spon, Ltd., 57 Haymarket, S.W.1. 44 pp. Price 4/- net.

It requires considerable courage to attempt to set up a table of standard prices at the present time, because the fluctuations in the price of materials and the decreased output by the workers are items which cannot be estimated with any great accuracy, and it is quite customary for estimates to be given on the understanding that variations which occur in the price of materials or rates of wages during the execution of the work will be allowed for in the settlement of the accounts.

The author has dealt with the matter under three general items in order to give some comparison between present-day prices and those ruling in August, 1914, as follow :—(*a*) increased rates of labour, (*b*) decreased efficiency and output of labour, and (*c*) increased cost of materials. He gives various tables which he has prepared to show the ratios of labour and materials, the average rates of wages paid, the percentages of increase, and various other comparisons which are extremely interesting. One of the principal tables, however, is that giving a schedule of building prices wherein the average cost in August, 1914, and June, 1919, are compared, and it is to this table that the estimator will naturally turn for guidance when pricing work to-day. Upon making a few comparisons, however, there appears to be a certain amount of inconsistency in the tables, because if the price of materials and labour for a particular class of work are taken from the author's tables and a total arrived at it will not agree with the schedule price as stated by him. As an example we may take Portland cement concrete (1 to 6) which is given in the schedule as worth 31s. 8d. per cu. yd. Now this appears to be very low for the average cost in June, 1919, and upon reference to the price of materials in June, 1919, as given by the author, we shall see that gravel or ballast is quoted at 11s. 6d. per cu. yd., sand at 12s. 6d. per cu. yd., and Portland cement at £3 5s. per ton. Now a cu. yd. of concrete mixed requires the following quantities of these materials. Aggregate about ·92 cu. yd., sand ·46 cu. yd., and cement 560 lb., and if these are priced out we get aggregate 10s. 7d., sand 5s. 9d., and cement 16s. 3d., which equals 32s. 7d. per cu. yd. for materials alone, and this is more than the price given for the material when mixed. By the time that the cost of labour is added, which, according to the author, should be equal to about 15 per cent. of the total cost, the price for a cu. yd. mixed would be about 38s. 4d.

The same inconsistency appears in the case of several other materials, and thus the schedule of prices can hardly be looked upon as a reliable guide to present-day prices.

The author has a good reputation in costing and estimating work, and we feel that it is a pity he should publish a volume that is open to such severe criticism.

### Spons' Architects' & Builders' Pocket Book Price Book, 1920.

London: Messrs. E. &. F. N. Spon, Ltd. 6s. net.

This publication is now so well known among our readers that it needs little on our part to commend it to those for whom it is specially compiled. It is recognised amongst architects and builders as a handy and reliable reference book, and is issued in a convenient size for pocket use.

### Laxton's Builders' Price Book, 1920.

Kelly's Directories, Ltd., 182 High Holborn, W.C.1.

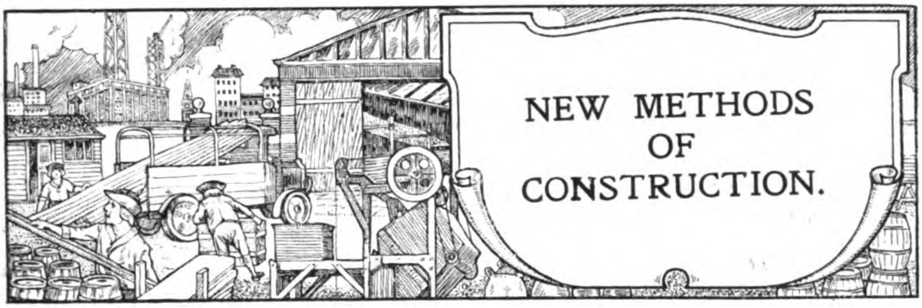
This valuable reference book, which is now in its 103rd Edition, has been somewhat delayed in its publication this year, owing to the rise in wages which occurred last November. Every effort has been made by the compilers to see that information under this head should be as accurate as is possible.

The List of Specialities of Trade Marks of Materials and Manufactured Articles used by the building trades has been extended in the present edition where necessary. Special care has been given to the section dealing with electric lighting.

A short review on Reinforced Concrete is also given under the head of "Fireproof" Construction.

### Useful Data on Reinforced Concrete Buildings. Price, $2.50.

A book under this title has been compiled and arranged by the engineering staff of the Corrugated Bar Co., of Buffalo, N.Y. It contains data on reinforced concrete buildings which should be of use to the designer and estimator. There are also formulæ for reinforced concrete design and a large number of useful diagrams and tables.



*In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—Ed.*

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## THE CHANNELLO SYSTEM.

In a previous issue we made some reference to the Channello system, when giving an account of the Building Trades' Exhibition. The accompanying detailed diagram (see next page) will give a more comprehensive idea of the method adopted in this form of construction, which may be briefly described as follows :—

A Standard Channel-shaped concrete block as is shown in *Fig.* 1 is used for the walls, floors and roof, all four edges of the blocks being grooved to ensure good joints. The wide flanges provide sufficient surface for making vertical joints, and as they do not touch the surface of the inner block, a continuous cavity wall is ensured, even at the corners. At present the blocks are made in two standard sizes, 24 in. by 12 in. and 18 in. by 9 in. They are made under pressure on special machines, one a hand machine for small jobs, and a power-driven machine for turning out large quantities. The process of manufacture allows the blocks to be made of the minimum thickness compatible with strength and stability.

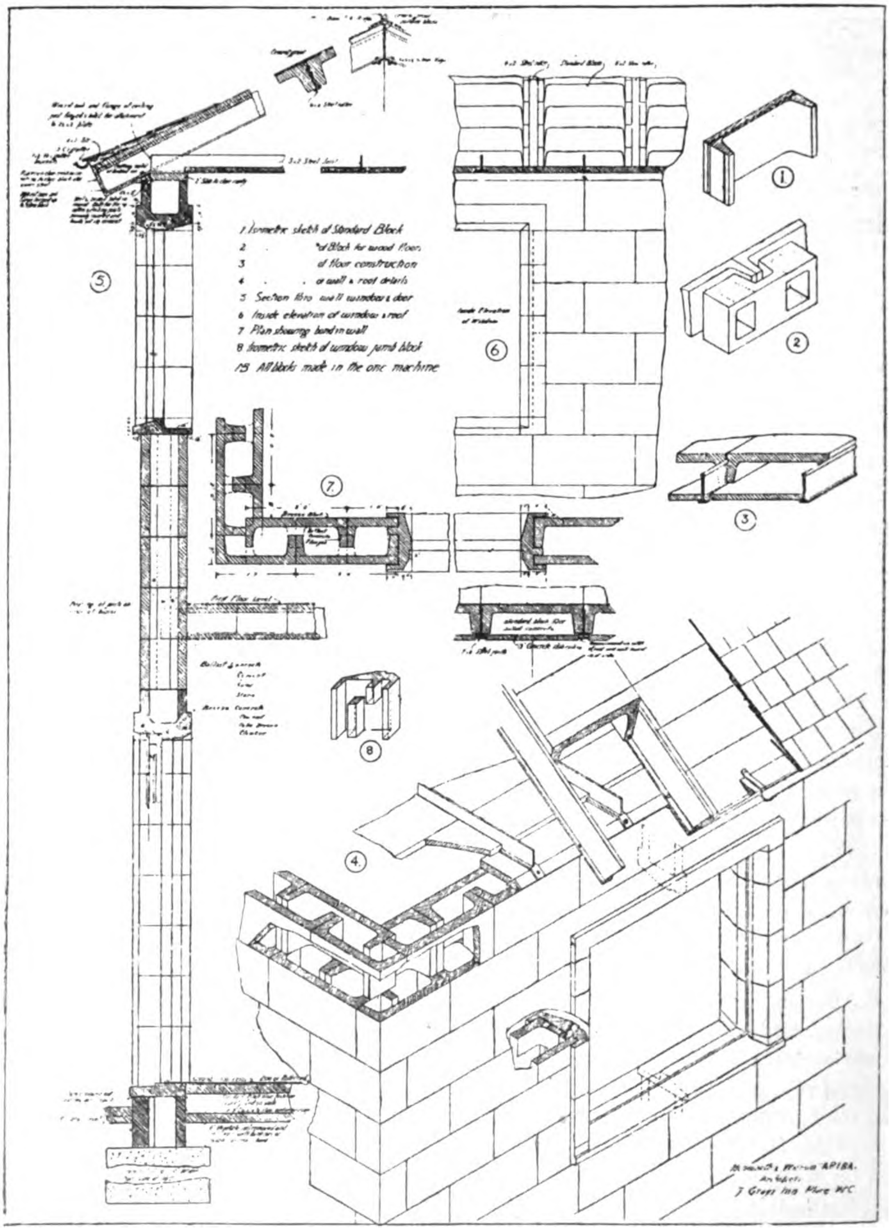
The construction of the walls is shown in *Figs.* 5 and 7. The outside slabs are made of ordinary ballast concrete, cement, sand and stone, and the outside surface may be left either plain or can be moulded to different designs. The inside blocks are of clinker concrete with ballast concrete flanges, thus providing a continuous ballast concrete column down the interior of the wall.

A special architrave block is made for openings, which are dealt with as shown in *Figs.* 6 and 7. An alternative treatment is possible, but the one shown is simple. These architrave blocks are made on the same machine as the slabs. Lintels are made of reinforced concrete. The ground floor may be made of blocks laid on slabs, and the first floors are dealt with as shown in *Figs.* 3 and 5. The roof (see *Figs.* 4 and 5) is of similar construction to the floor, but lighter, and the slabs are clinker concrete laid on steel beams. The surface of the roof is covered with slates nailed to fillets.

Both pitched and flat roofs may be used.

As regards heating, a flue construction of blocks provides a hot-air circulating system for heating the whole house.

All further particulars can be obtained on application to the Secretary, Channello Construction Co., 8, Warwick Court, Gray's Inn, W.C.1.

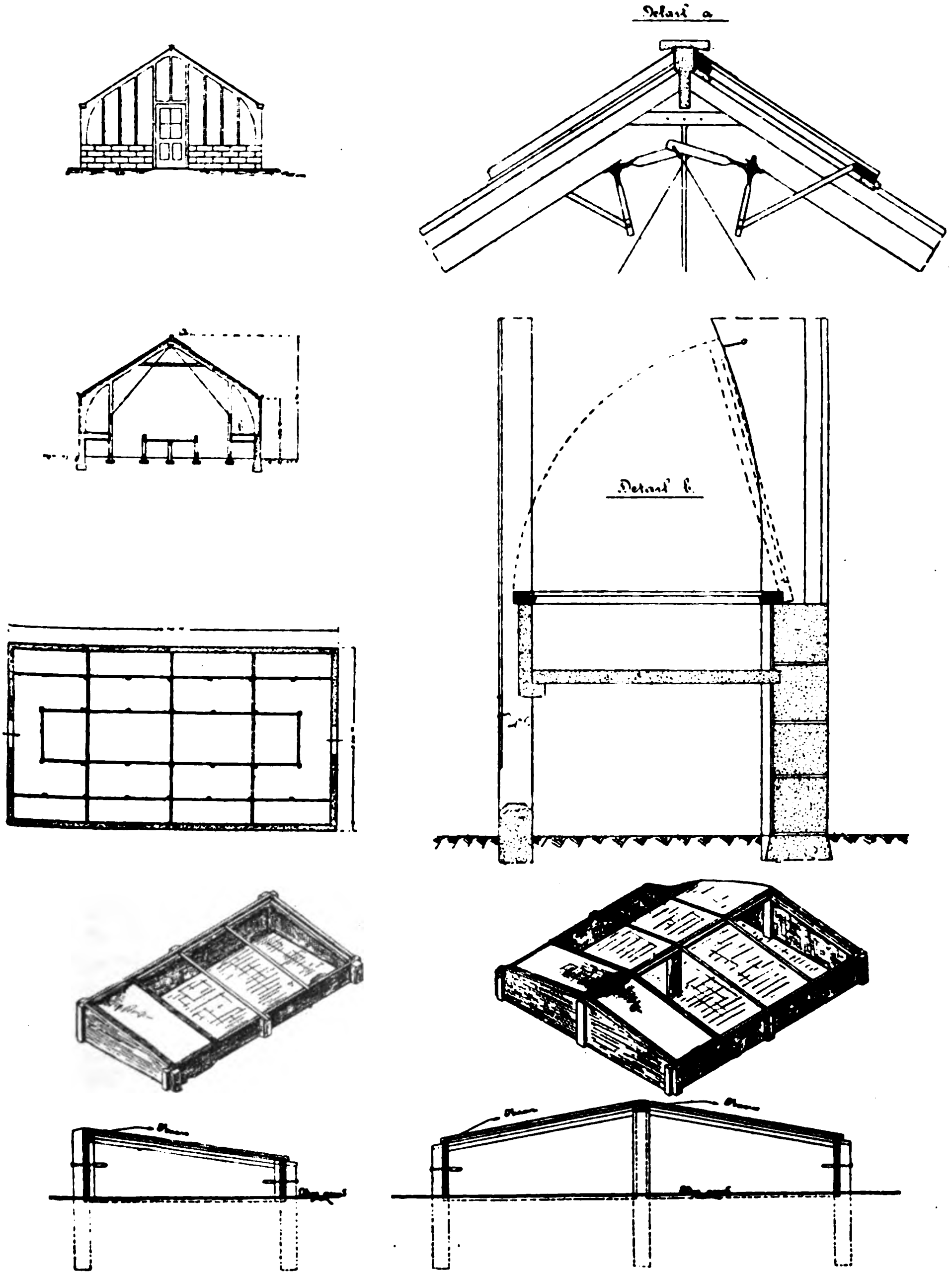

1 Isometric sketch of Standard Block
2 " of Block for wood floors
3 " of floor construction
4 " of wall & roof details
5 Section thro wall window & door
6 Inside elevation of window & roof
7 Plan showing band in wall
8 Isometric sketch of window jamb block
NB All blocks made in the one machine
①
②
③
④
⑤
⑥
⑦
⑧
3x3 Steel Joist
Standard Block
Inside Elevation of Window
First Floor Level
standard block floor
A.R.I.B.A.
Architects
7 Grays Inn Place W.C.

THE "CHANNELLO" CONSTRUCTION SYSTEM.

# THE FOREIGN PRESS.

*The following are abstracts taken from the foreign Press relating to concrete construction.—ED.*

**Concrete for Horticultural Structures.**—Concrete may be used with advantage for many horticultural purposes. For instance, where very large forcing frames are



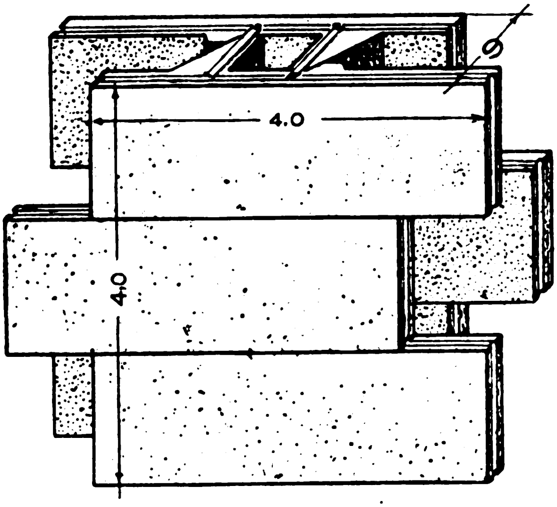
Details of Construction.
CONCRETE FOR HORTICULTURAL PURPOSES.
*Reproduced from "Gewapend Beton"*

used, they may be constructed wholly of reinforced concrete and glass. Greenhouses may be cheaply and very strongly built of concrete instead of brick and wood, and if sufficient attention is given to the details of construction, such structures will be found to be better in every way. No great architectural skill is required, and the accompanying illustrations are self-explanatory. They are taken from *Gewapend Beton.*

**The Ambi Block for Houses.**—What is known as the " Ambi " system of concrete construction has been specially designed for two and three storey houses, for which some other concrete blocks are not suitable, excellent though they may be for single storey structures such as bungalows.

As shown in the illustration, the blocks consist of a flat slab measuring 40 in. by 13 in., with a projecting piece about 3½ in. long and a second projection about 1 in. long, these projections being arranged so that when two blocks are brought together, as shown in the illustration, they enclose a small rectangular space. The blocks are held in position by short clamps composed of iron rods cut to a suitable length and having their ends bent at right angles so as to fit into the grooves which run all round the blocks. For one square metre (=1600 sq. in. or rather more than 11 sq. ft.) six blocks are required. If desired, the interior block may be made rather thinner than the outer one, namely 2 in. and 2½ in. respectively, the projecting pieces being made of such a length that the total thickness of the wall is exactly 9 in.

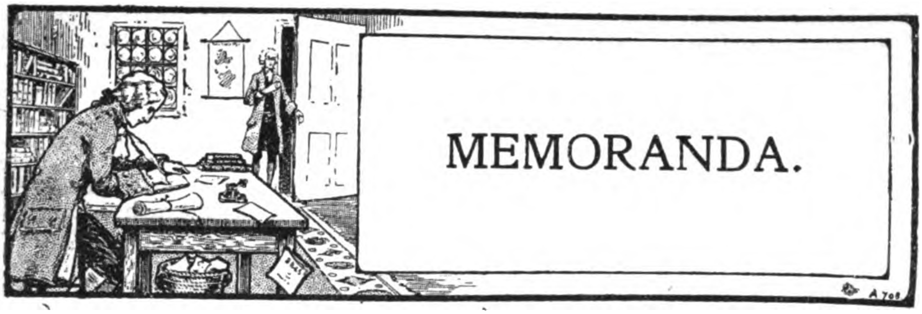
The inner block is made of a soft concrete into which nails can be driven, a breeze concrete being largely used, or a mixture of 1 measure of cement, 2 measures of sand and 4 measures of coke dust, the outer block being made of a weather-resisting concrete. The blocks are easy to make, two men producing 40-45 blocks in a day of 8 hours. The blocks are made in wooden moulds and not in machines.



The blocks are arranged as shown and are laid in cement mortar. In each course the blocks are reversed so that the large projection lies on a small one and thus produces a good key. When the wall is within 9 in. of the desired height, a reinforced concrete beam made of the same material as the inner blocks is laid on it so as to take the weight of the roof and distribute it uniformly on the walls. By this means the disadvantages of carrying the structure on beams and pillars is wholly avoided.

The cavities in the walls may be filled with ashes, clinker, sand, gravel, etc., but the small rectangular space between the projections should be treated separately. In single storey buildings it may be filled with any of the materials just named, but for two storey buildings it should be filled with concrete and in higher buildings with reinforced concrete.

Door and window openings are adjusted by means of a special block, and these openings are independent of the length of the concrete blocks, as the latter can be made shorter than shown if required.—*Tonind. Ztg.* 1920.



# MEMORANDA.

*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Royal Agricultural Show, Darlington.**—Many of our readers will doubtless visit the Royal Agricultural Show, which opens at Darlington on the 29th of the present month. All who do so should certainly inspect the collection of concrete articles and structures which will be exhibited at the stand of the Concrete Utilities Bureau. This exhibit, which is of a purely educational character, will be very comprehensive, and will form a striking illustration of the variety of ways in which concrete can be employed on the estate and farm, on the railway, and in works by public authorities.

The housing question, too, has not been forgotten, and the collection will include examples of many forms of construction of concrete dwellings and various kinds of roofing tiles and sheets.

Adjacent to this stand (No. 428) will be found others at which will be exhibited many types of up-to-date concrete machinery.

This assembly of all these stands in one section of the ground strikes us as a particularly good arrangement, since the visitor will be able to see, not only the finished articles, but the machinery by which many of them are made.

Demonstrations of block-making, fence-post moulding, etc., will be given at frequent intervals daily, and pamphlets issued by the Concrete Utilities Bureau, describing concrete products and how to make them, may be obtained at their stand.

**Reinforced Concrete School Building.**—A proposal to erect, at a cost of £20,000, a reinforced concrete school building to accommodate 648 children has been agreed to by the Birkenhead Education Committee.

**Building in France.**—According to *La Nature*, the shortage of workers and the pressing need of buildings in the Departments devastated during the war has led to new devices in which the saving of time and the reduction of hand labour are prominent. In the process of M. Ch. H. Besnard, an architect of the Government, elements of reinforced concrete are moulded in the factory under favourable conditions of temperature and humidity, where workmen are on the ground and not in mid-air, and where inspection and tests can be carried out with satisfaction. In erection a skeleton, consisting of posts carrying at the upper end very stout metal gutters, and horizontal girders connecting the posts, is put up. The gutters themselves serve as lengthwise girders. From the peak of the roof descend the two sloping sides of glass or of tile, and both rest upon the inner edges of the gutters on the two sides of the structure. Outside of the actual elevation of the members and of their fixing in place but little work need be done at the site of the structure. The roof has only three joints. The same process is applied to dwelling houses as well as to factories, and in a characteristically French manner the æsthetic features of the structures are cared for. It is reported that a saving of more than 90 per cent. in the number of workers at the building itself is thus made—no inconsiderable matter in view of the 450,000 ruined buildings in France.

**Reconstruction in France.**—Recent news from France calls attention to the extensive use of concrete in connection with the restoration of the war-devastated areas. Most of the houses in these areas were built of brick or stone, but even by using bricks and such stone as is ready and available it is not possible to get the work done as quickly as desirable. The difficult question has now been solved by the use of concrete, which is easily obtained, as sand is plentiful, and concrete houses, barns and workshops are springing up rapidly everywhere. Even the roofs are made of concrete, being moulded instead of laid on. Boards are placed over the roof and then a layer of concrete poured over them. In order to relieve the plain grey appearance of the new concrete buildings, very tasteful schemes of decoration are being carried out, so that the rural appearance of the new villages will be preserved.

Another important use to which concrete is being put is for telegraph poles.

Reinforced concrete will also play a large part in the reconstruction of the many fine bridges which had to be destroyed during the war.

**Concrete Mine Shaft-Houses.**—The *Technical Review* gives a short abstract from an article describing some concrete shaft-houses erected for the Cleveland Cliffs Iron Company, and it is stated that this company are among the pioneers in adopting concrete for this purpose. Work on two such shaft-houses, the first of their type to be built in the Lake Superior district, was begun in August, 1919. A novel feature in their construction is that the concrete was poured into forms built entirely outside the old wooden and sheet-iron shaft-houses. The work was carried out without causing any interruption of the hoisting. These houses are 33 ft. square inside at the base, and 21 ft. at the eaves. The walls are 2 ft. 9 in. thick at the base, and batter in to 12 in. at the height of 10 ft. They are 98 ft. 9 in. high above the footings. Seventeen hundred tons of concrete was poured in each structure. To improve their appearance, it is intended to coat their outer surfaces with finely powdered iron ore.

**Ghent.**—In view of the steady increase of cotton importation at Ghent, the administrative authorities of the town have decided to erect two large warehouses capable of storing 30,000 bales of cotton each. The warehouses, which will be at the New Basin, are to be constructed of reinforced concrete and bricks. There are to be two floors. The cost of construction is estimated at 3,850,000f. and the work is to be completed in eight months.

The administration of Ghent has also decided upon the reconstruction of the entrepôt at the dock, destroyed by fire last year. The new building will be erected upon the old foundations, will be isolated, and rendered completely fire-resisting, and will take 15 months to complete. The estimated cost is 1,825,000f.

## HOUSING NOTES.

**Grants for New Methods of Construction.**—The Ministry of Health announces that where special forms of construction are adopted to rank for the Government subsidy, the following conditions must be complied with :—

*Concrete Walls.*—Grants will be payable for the full amounts if the walls are constructed of concrete and the rest of the house is in accordance with the specification of Part 2 of Schedule 1 of the Memorandum on "Grants to Private Persons . . . under the Housing (Additional Powers) Act, 1919." The composition of the concrete must be in accordance with the Ministry's specifications for concrete blocks or walls. The external and party walls may be constructed of concrete blocks 3 in. thick, with a continuous cavity of 2 in., or of blocks 2 in. in thickness with a continuous cavity of 2 in., provided that in the latter case the blocks are provided with approved stiffeners and webs, and in both cases that the two thicknesses are properly tied together with galvanised iron wall ties or by any other approved method. No internal weight-bearing wall shall be constructed of a less thickness than 3 in. The ends of joists and the bearing plates shall not project beyond the cavity face of the inner wall. If cavity blocks are used of the full thickness of the wall they shall not be less than 8 in. in thickness, and proper provision must be made for carrying the floor and roof plates without breaking into the cavity of the wall. Where walls are built of monolithic concrete they shall be in accordance with the Ministry's "Specification for Concrete Walls built *in situ*." Where reinforced concrete floors are used, they must be calculated to carry a live load of 56 lb. per sq. ft., in addition to the weight of the floor, with a factor of safety of one-quarter of the tested breaking load.

*Cavity Walls Constructed with Brick on Edge.*—Walls may be constructed of bricks on edge with a 3 in. cavity, headers and stretchers being used alternately in the same course, but the exterior of the walls must be finished in cement rough cast.

*Walls Constructed partly of Brick and partly of Concrete.*—Houses constructed with a cavity wall, the outer part of which is constructed in 4½ in. thick brickwork, with a cavity and the inner part of concrete, not less than 2 in. thick for one storey, or 3 in. thick for two storeys, will be eligible for the full amount of the subsidy, the rest of the work being in accordance with the specification in Part 2 of Schedule 1 of the Memorandum.

*Pisé or Clay-Lump Construction.*—Grants will be payable for the full amount for houses constructed in pisé or clay-lump, provided that the work is carried out under proper technical supervision and with suitable material of a sufficient thickness, and not less than 18 in. for *pisé* and 12 in. for clay-lump, with damp-courses both at the foot and on the head of the wall; the rest of the work being in accordance with the Specification in Part 2 of Schedule 1 of the Memorandum.

*Iron or Steel-Framed Structures.*—Grants will be payable for the full amount for houses constructed with iron or steel-framed walls, provided that the whole of the steel frame-work of the walls employed in the construction is protected from rust by a casing of cement concrete of sufficient thickness and not less than ¾ in. in any part. The walls must be constructed as cavity walls, with an external cement or plaster face of not less than 1½ in. in thickness and with a plastered inner face or concrete slab lining. The steel framing may also be faced with concrete slabs built as curtain walls. All metal lathing must be thoroughly embedded in plaster and protected from rust. Large scale drawings must be submitted for this method of construction showing details of connections for approval by the local authority.

*Timber Frame Houses.*—Timber-frame houses will be eligible for two-thirds of the subsidy and must conform with the Ministry's Specification for timber-frame houses so far as the timber framing and its covering is concerned; the rest of the work being in accordance with the Specification in Part 2 of Schedule 1 of the Memorandum.

*Matchboarding.*—Matchboarding cannot be allowed for internal linings.

**Large Housing Scheme at Tilbury.**—An extensive housing scheme has just been started at Tilbury, for which the first sod was cut in the middle of May by the Chairman of the Tilbury Council (Mr. Alex. Brennan, J.P.). The scheme comprises 1,520 houses. A large number of the houses will be erected near the Thames and on alluvial soil, which gives an insecure foundation. For this reason the site will be covered with reinforced concrete, the contract for this work having been let to Messrs. Christiani & Nielsen, of Victoria Street, Westminster.

The roads and sewers and flood-prevention works are to be constructed in reinforced concrete—B.R.C. Company's wire mesh—the contract for which is £226,025.

Mr. S. A. Hill-Willis, the Council's Engineer and Surveyor, is responsible for all the engineering work, including the concrete rafts over the site, whilst the architects are Messrs. W. J. Wadman, M.S.A., 71, Jermingham Road, New Cross, and F. J. Winter, M.S.A., 2, Heygate Avenue, Southend-on-Sea.

The engineering contract now starting comprises the lay-out of a new civic centre, with sites for police court, child's welfare, fire station and municipal buildings, public baths, library and large shops. The reinforced concrete carriage-ways will be provided with green margins and artificial stone footways tree-lined on the boulevard principle. Tunnel sewers are being driven through the hills one mile back from the port in order that not only the new housing estates can be dealt with on modern sanitary lines, but that the ancient village of Chadwell will be enabled to abandon its primitive cesspool system.

The flood-prevention works will include the deepening of the open sewers and the placing down of a reinforced concrete invert and sides for a length of 1¼ miles. These works will permit rainwater in times of heavy rainfall to be stored during periods of high tides without risk of flooding.

**An Ideal Village.**—The site chosen for the "Daily Mail" Ideal Village is near Welwyn, Herts, 21 miles from London. Every arrangement has been made to help and accelerate the work of those firms who wish to build houses.

So that the work may be as artistic as it is quick, the plans of the builders will all go to Mr. Raymond Unwin, F.R.I.B.A., the well-known town-planning expert.

**Bournville.**—We referred in a previous issue to an interesting experiment which was being carried out at Bournville to ascertain the cost of erecting houses of different materials. The Bournville Works Housing Society, Ltd., before erecting additional brick houses on the Bournville estate, decided they would not be justified in accepting tenders without investigating alternative methods. These methods, it will be recollected, were to include concrete, timber, and pisé de terre. The wooden bungalow is now practically completed, and another of brick and concrete is in course of construction. Two concrete houses are well in hand: these are being built of Winget concrete blocks. An important point to be noted is that the experiments are to extend to the interiors of the houses, and advantage is being taken of the opportunity to ascertain the cost of installing various modern labour-saving devices and other improvements.

**Contracts under the Housing Act.**—At the end of April contracts had been placed under the Housing Act for 7,100 concrete or reinforced concrete houses, against 19 contracts for houses with wooden frames. The concrete houses are actually about one-seventh of the total number of houses for which contracts have been placed. Sheffield, whose deficiency of houses is officially estimated at 14,986, has only begun concrete building on a small experimental scale, putting down a dozen cottages in pairs to test different methods of concrete construction. A large number of the northern towns are proposing to use concrete for part of their housing schemes. Nottingham is experimenting similarly. Barnsley thinks of building 100 concrete houses. Cudworth, Hemsworth, and Doncaster are considering a similar number. Beverley has placed contracts for 145 concrete houses. Rotherham Corporation propose 150, and 100 others are being arranged for in the borough. Scunthorpe proposes 400, and Lincoln, where 2,588 houses are needed, is also likely to try concrete.

**Manchester.**—The Housing Committee has accepted the contract from the Waller Housing Corporation for 500 houses to be built of reinforced concrete slabs. The first 370 are to be erected at Newton Heath and the remaining ones will be distributed among various housing estates in Manchester. The houses are to be two-storeys. There will be a parlour and kitchen, and the number of bedrooms will vary, some houses containing two, others three bedrooms.

**Swansea.**—Three specimen concrete houses are to be erected at West Cross, near the Post Office. The cost of each will probably be about £750. If the scheme prove successful it is the intention of the builder to put up a big number.

**Langbank**—A recent number of the "Bulletin" gave some illustrations of a concrete house built at Langbank, as an experiment, on the Nelson Patent Concrete Construction, standardised parts being used in the erection of the houses. An illustration of a cottage built on this system with constructional details appeared in our issue of June, 1919. The system was devised by Mr. Walter Wilson, of Dunfermline.

**Housing Congress, Lyons.**—A second Congress was held at Lyons during March of this year to deal with the housing question in France, and the report of the Congress proceedings has just been published. Every aspect of the housing problem was considered, the need for cheap dwellings being accorded particular attention.

## ROAD NOTES.

**Newbury.**—An interesting example of concrete road construction is proceeding in Northbrook Street, Newbury, where the Borough Surveyor, Mr. S. J. L. Vincent, is laying a complete concrete road.

**Marylebone.**—Some reinforced concrete road foundation work is now being carried out at Allsop Place, Marylebone, under the direction of the Metropolitan Borough Surveyor, Mr. J. P. Waddington.

In both instances the reinforcement which is being used is B.R.C. Fabric, Ref. No. 9.

We also learn that a Lakewood Mixer is being employed with very satisfactory results at Marylebone.

## NEW METHODS AND MATERIALS.

The following is a list of materials and new methods of construction approved by the Standardisation and Construction Committee :—

THE EDWARDS CONSTRUCTION COMPANY, SIEBERT WORKS, WESTCOMBE HILL, BLACKHEATH, S.E.3.

*The " Forrester-Marsh " System.*—A system of monolithic concrete construction in the form of thin walls with a continuous cavity between ; both the inner and outer walls are reinforced with steel, and when the centreing for the cavity is removed the two leaves are tied together with galvanised bolts embedded in concrete.

R. D. ATHERTON, LILAC ROAD, HALE, NEAR MANCHESTER.

A system of combined steel and concrete construction, the buildings being framed up as a skeleton in steel, the walls being formed with slabs on both faces, the space between being filled in with concrete, either solid or with a continuous cavity. The steel in the cavity is dressed with concrete.

J. A. CALVERT, 210, ELM ROAD, LEIGH-ON-SEA, ESSEX.

*The " Domkonstruado " System.*—Reinforced concrete cavity wall construction with pre-cast units, stanchions and beams ; the filling between these for the other skin is concrete in situ with a wired reinforcement. The inner skin is built up either with clinker or plaster slabs. The floors are framed with pre-cast reinforced beams with wood joists and plates.

W. S. GRICE, A.R.I.B.A., 9, GRAY'S INN SQUARE, W.C.I.

*" Duplex Sheath " Construction.*—The structure is a skeleton steel frame which is embedded in concrete.

CONCRETE DWELLINGS, LTD., 5 AND 6, GREAT WINCHESTER STREET, LONDON, E.C.2.

*The " C.D.L." System of Construction.*—The apparatus employed consists of a mould or machine placed on the foundation of the building, and filled with concrete which is sufficiently rammed The sides and core are rigidly held in position during ramming, after which, by means of an expanding and contracting mechanism, the machine can be moved forward to the extent of its length to build the next section of the wall.

A. STANLEY COX, 16, QUEEN VICTORIA STREET, READING.

*Cox's System.*—The lower part of this construction is the usual concrete block or slab construction. The upper part consists of segmental roofing slabs with a cavity with rebated joints at ends and sides supported on " T " steels, the form of roof when completed being of a barrel section and protected on the outer face by a coating of waterproofing material.

THE TRENT CONCRETE COMPANY, WILFORD STREET, NOTTINGHAM.

A system of cavity wall concrete construction, the outer thickness of the wall being pre-cast reinforced concrete and the inner built up with clinker concrete slabs. The floor and roof are also formed of pre-cast units which are assembled together on the site. This method is suitable for buildings of one storey in height.

## PERSONAL.

Mr. W. Matthews Jones, M.Inst.C.E., who has retired from the office of city surveyor of Chester, has commenced private practice as an engineer and architect at 56, Foregate Street, Chester. He intends to specialise in all classes of work relative to reinforced concrete roads, bridges, buildings, etc., while also entertaining the subjects of sewerage and sewage disposal, as well as general road construction and building.

## CONCRETE AND HOUSING SCHEMES.

The following tenders have been accepted for the erection of concrete houses :—

LONDON (DEPTFORD).—The Borough Council has accepted the tender of Messrs. Edwards Construction Co., Ltd., of Blackheath, for the construction of 187 concrete houses, at a basis price of £158,950.

BARNSLEY.—The Barnsley Housing Committee has accepted the tenders of the New Era Concrete Construction Co., Ltd., for the erection of 17 Type " B " houses at £935 each ; 14 Type " I " houses at £950 each ; and 3 Type " F " houses. The houses are to be erected on the Racecommon Road site.

ILFRACOMBE.—The Ilfracombe Urban District Council has provisionally accepted the tender of Mr. W. Pile for the erection of 14 concrete houses, at £850 each.

PLYMOUTH.—The Town Council has accepted the following tenders for the erection of concrete houses : Mr. E. E. Endicott, two houses on the Dorman, Long system, at £804 each ; Mr. J. A. F. Hall, two houses constructed of " Hall's " concrete building blocks, £1,550.

ST. COLUMB.—The St. Columb Rural District Council has accepted the tender of the Lightning Construction Co., of London, for the erection of 54 monolithic concrete houses, for £44,456.

ILFORD.—The Ilford Urban District Council has accepted the tender of Messrs. Pettigrew, of Ilford, for the erection of two concrete houses, at a cost of £1,620.

NOTTINGHAM.—In connection with the scheme of the Ministry of Health to erect sample cottages built on special methods of construction in various centres, the Nottingham Corporation has set aside an area of 4½ acres on the Sherwood site for the purpose, and the following tenders have been accepted :—Messrs. Walter Jones & Co., one pair of houses, at £1,580 ; Economic Building Corporation, Ltd., one pair of houses, at £1,500 ; the Minniel system, one pair of houses, at £1,450, plus £45 for fences and drains ; J. A. F. Hall, one pair of houses, at £1,500 ; Messrs. Panels, Ltd., one pair of houses, at £1,470.

A SOUTH AFRICAN CONCRETE TANK.—The Johannesburg Municipal Council has accepted the tender of Messrs. Fraser & Chalmers, Ltd., of Erith, for the erection of a reinforced concrete tank of 50,000 gallons capacity at the abattoir, at a cost of £2,750.

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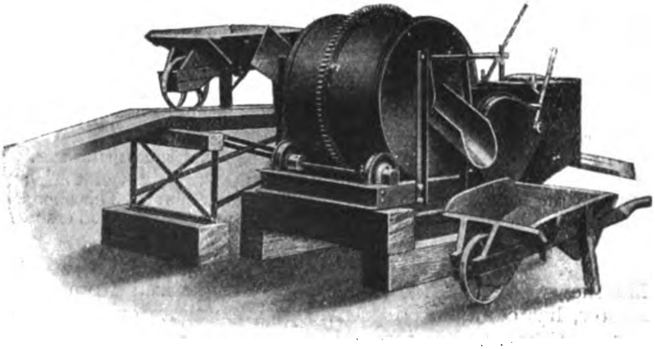

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## TRADE NOTES.

**The Manufacture of Portland Cement.**—Two interesting pamphlets have just been issued by the Wouldham Cement Company, Ltd., dealing with their works at Grays, Essex. One of the booklets gives a pictorial description of the manufacture of Portland cement; starting off with illustrations of the chalk quarry and the unloading of the materials at the company's works jetty, we are shown the process of manufacture from start to finish. The second pamphlet, which is also well illustrated, contains interesting information regarding the testing of cement, and also gives some illustrations of important engineering structures where cement concrete was largely used in the construction.

**National Shipyards.**—At the recent sales by auction of some hundreds of Winget machines—chain-spade mixers as well as concrete block-making machines—the prices realised were on the average little less than the original ones paid for them: and this after many months of useful war work. The pallets also realised exceptionally high prices.

**Electric Arc Welding applied to Reinforced Concrete Construction.**—The rapid development and extension in the use of reinforced concrete for constructional work is naturally bringing to the front minor problems connected with its practical application. The Alloy Welding Processes, Ltd., have sent us one of their Bulletins calling attention to the advantages of electric arc welding in connection with reinforced concrete construction, in which it is stated that the methods usually employed to join reinforcing bars to girders and meshes leaves considerable room for improvement.

The present system of "tying" members together with iron wire has many disadvantages, and it is claimed that the adoption of electric arc welding overcomes these, and at the same time shows considerable economy in time and labour. The process is simple and requires no special skill on the part of the operator.

Several timed tests have recently been carried out at a shipyard where concrete barges were built, in order to ascertain particulars relative to the speed and economy secured with electric welded connections.

It was then clearly shown that a labour economy of 33⅓ per cent. was effected by substituting arc welding for the method of tying by wire.

As regards cost, it has been found with a Number 10 electrode at a price of 2d. it is possible to make 20 joints, equivalent to 10d. per 100 joints. The welded junctures of main rods have also been tested for tensile strength.

For full particulars apply to Alloy Welding Processes, Ltd., 14-16, Cockspur Street, S.W.1.

## PUBLICATIONS.

**Works Committees and Industrial Councils.**—By the Rt. Hon. J. H. Whitley, P.C., 1s. net.; University Press, Manchester; Longmans, Green & Co., London.

## NEW COMPANIES.

LEWES PRYSE & FOSTER CO., LTD. (166,797), 13, North Parade, Aberystwyth, Cardigan.—Registered April 24th. Manufacturers and dealers in concrete blocks. Nominal capital, £2,000 in 1,500 cumulative preference shares and 500 ordinary shares of £1 each. Directors: W. E. Foster, Stockfield Park, Wetherby, Yorks; and L. T. L. Pryse, Gogerddan, Bow Street, Cardigan. Qualification of directors, 100 shares; remuneration, to be voted.

THE DUPLEX SHEATH CONSTRUCTION CO., LTD. (166,870). Registered April 28th, 6, Moorgate Street, E.C.2. Builders and contractors. Nominal capital, £5,000 in 5,000 £1 shares. Directors: J. A. Wallis, Lulworth, Queen's Avenue, Maidstone, and F. C. Ehaler, 34, Fairholme Road, London, S.W. Qualification of directors, £250; remuneration to be voted.

HALLS CONCRETE CONSTRUCTIONS, LTD. (167,038).—Registered May 3rd, Cannon Street Buildings, E.C. To carry on the business of builders. Nominal capital, £20,000 in 15,000 ordinary £1 shares and 20,000 deferred ordinary 5s. shares. Directors: J. A. F. Hall, 105, High Street, Uckfield, Sussex, and J. Geddie, "The Ramblers," Scrubwood, Wendover. Qualification of directors, other than the first, £500: remuneration, 1,000 guineas, to be divided.

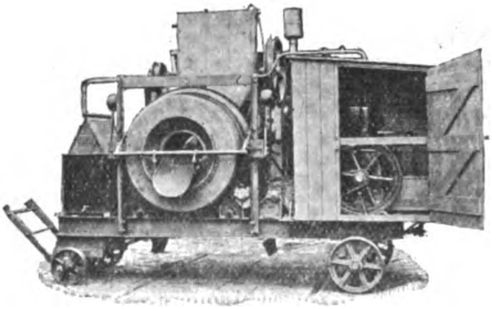
BRISTOL CONCRETE CO., LTD. (165,200).—Registered March 13th. Blackwell, near Bristol. Manufacturers of concrete and concrete articles. Nominal capital £2,000 in 1,000 6 per cent. cumulative preference shares of £1 each and 1,000 ordinary shares of £1 each. Directors: A. C., A. F., and F. E. Games, Holcombe, Somerset. Qualification of directors, £50; remuneration to be voted by company (managing director, £200).

WARRINGTON CONCRETE & PLASTER CO., LTD. (165,394).—Registered March 17th. Concrete and plaster slab and block manufacturers. Nominal capital £5,000 in 5,000 £1 shares. Directors to be appointed by subscribers; remuneration to be voted by company. Subscribers: A. Tilling, 27, Walton Crescent, Lower Walton, Warrington, and H. Osborne, 124, Ellesmere Road Lower Walton.

LUDA CONCRETE PRODUCTS, LTD. (166,140).—Registered April 8th. Eve Street, Louth, Lincs. Manufacturers of concrete products. Nominal capital £10,000 in 10,000 £1 shares. Directors: H. R. Thompson, P. G. Blake, and C. F. Ward. Qualification of directors, one share; remuneration to be voted by company.

## PATENT APPLICATIONS.

140,158.—F. Peters: Moulds for concrete blocks.
140,284.—B. Scruby and G. K. Harkness: Concrete moulds.
140,312.—W. H. Smith: Building blocks.
140,353.—W. G. Cook: Concrete walls.
140,492.—G. Towle and G. Herbert: Shuttering for concrete construction.
140,556.—S. G. Palmer and A. E. Cuckow: Building construction.
140,581.—W. A. Millward and J. S. Walton: Shuttering for concrete construction.
140,636.—K. K. Dyson: Floor and wall construction.
140,729.—W. G. Cook: Window and door construction for concrete buildings.
140,874.—T. F. Hoare: Process for the use of slag as a building material.
140,926.—T. V. Haigh: Building blocks.
141,086.—E. L. J. Le Breton and L. T. Surridge: Roof construction.
141,112.—F. C. MacCormac and J. W. Grundy: Concrete conveyors and distributors.
141,113.—H. C. Badder, S. F. Burrows and H. L. P. Allender: Cement and concrete waterproofing material.
141,142.—M. L. Boillet and J. Dandignac: Cement manufacture.
141,161.—M. S. R. Adams: Reinforced concrete construction.
128,542.—Massey Concrete Products Corporation: Apparatus for the manufacture of hollow concrete poles.
141,261.—H. H. Hodkin: Shuttering for concrete construction.
139,010.—T. Lant: Concrete block-making machines.
139,294.—T. E. Hardy: Stanchions and beams for hollow wall buildings.
141,460.—J. H. W. deWaller: Reinforced concrete house construction.
141,769.—G. A. Henderson: Bituminous concrete pavements.
141,811.—F. G. Linde: Concrete slabs.
141,857.—W. Johns: Building blocks.



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ISSUED MONTHLY

## CONTENTS.

**Editorials.**

**Concrete Work at U.S. Army Supply Bases.**

**Concrete Cottage Building.**
Housing Scheme at Folkestone.

**Pressure of Concrete Against Forms.**
By E. B. SMITH.

**The Adaptability of Reinforced Concrete.**
New Joiners' Shop for Messrs. Craig Taylor Co., Ltd.
By R. STUBBS, A.M.C.I.

**Mass Production of Cottages.**
Pre-Cast Reinforced Concrete Houses Erected by Machinery.
By "ANGLO-AUSTRALIAN RESIDENT ENGINEER."

**Concrete Roads at Newbury—Newbury Housing Scheme.**

**Renewal of Summerhill Bridge, Dublin, with Reinforced Concrete.**

**German Fire Tests on Reinforced Concrete Houses.**
By Dr. ARTHUR HOLMES, D.Sc., A.R.C.S., F.G.S.

**Concrete Shipbuilding.**
By ALFRED B. SEARLE.

**Notes from the Foreign Press.**

**Concrete in Theory and Practice.**
Reinforced Concrete Simply Explained. By Dr. OSCAR FABER, O.B.E., etc.

**Questions and Answers relating to Concrete.**

**Correspondence.** **New Books.**

**New Methods of Construction.** **Memoranda.**

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# CONCRETE
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Volume XV. No. 7. LONDON, JULY, 1920.

# EDITORIAL NOTES.

## A STANDARD METHOD OF MEASUREMENT FOR REINFORCED CONCRETE.

A YEAR before the war a joint committee representing the Quantity Surveyors' Association and the Concrete Institute met to consider some standardisation of methods for measuring reinforced concrete work, and the report of this committee in the form of a thirteen page pamphlet is now before us. Consisting of more than 40 members, under the chairmanship of Mr. S. Bylander, this representative body submitted its proposals to the R.I.B.A., the Surveyors' Institution, the National Federation of Building Trades Employers, and the Institute of Builders, whose suggestions were carefully considered. This report may, therefore, be regarded as representative of all the important interests concerned, and will doubtless form the basis for all quantity work on this subject in future. We need not occupy space in pointing out the necessity for uniformity in taking off reinforced concrete work. A unified system is long overdue, and a very valuable task has been accomplished. The report, which has been approved both by the Concrete Institute and the Quantity Surveyors' Association, deals with both " in situ " and pre-cast work.

Beginning with some general instructions, it has been laid down that concrete formwork and steel reinforcement are to be billed together, for each section of the work, such as a storey, and that the different materials are not to be separated under trades. This should greatly facilitate the adjustment of omissions and variations, since in such changes these three requirements necessarily stand or fall together.

The actual work is to be divided under the headings—foundations, struts, walls, beams, slabs, curved work, staircases, and pre-cast work. Work to be included under these headings is defined by reference, *e.g.*, beams are instanced as main beams, secondary beams, braces and cantilevers. First the shape and size of these members is to be stated, then the quantities of concrete, formwork and steel,necessary. But measurements are enjoined, the concrete in cubic feet, the formwork, super, the steel in pounds, and any special work, linear, super, or numbered, as most appropriate. As regards concrete, the contractor is to be informed that though proportions are given by volume the cement is to be put in by weight. This use of different units is a great weakness in our measurement systems, and is often not sufficiently emphasised in specifications. Volume and weight proportions are quite priceably different, and on a job the former method of measurement is alone practicable. On the other hand, transport companies invariably charge by weight, though merchants sell some national materials by volume. We think that it would be of great national assistance if some unification could be arrived at in this matter, and commend the subject to the attention of those concerned. It is left to the contractor to add to formwork, which is measured super, the cost of overlaps, battens, strutting, fillets and the like, and we assume that the committee came to the conclusion that the factor for these additions is sufficiently constant to justify this omission on the part of the surveyors.

As regards steel, main bars ½ in. to 2 in., every size below ½ in., bars over 30 ft. long, stirrups and links, hooping, and meshwork, are to be kept separate. These items are to be described as fixed in position complete.

The report proceeds to describe particular items. For example, in the case of beams, the shape and position, whether attached to pillars, relation of depth to width, whether main beams and if chamfered or curved, and so on, must be made clear.

The last four pages are devoted to pre-cast work. The time for execution is to be given in order that the number of moulds may be judged in repetition work and the necessary hoisting and fixing fully described. A further statement as to whether surfaces are left rough for plaster or finished to a fair face is required. For floor slab work a short example of the quantities is given as a general guide to the method to be adopted. Finally, piles are described in some detail. These are to be numbered, after a full account of their construction, size, and final situation.

In the early days of reinforced concrete work specialists were so largely resorted to that the question of quantities was not a very urgent one. Now, however, so much work is designed without reference to any patent system that quantities have become a very important matter, and we feel sure that this report will be most welcome, both to surveyors generally and to builders' estimators. It is terse and free from anything unnecessary to the object in view, and therefore will form a very useful and usable reference, and we feel sure that it should advance the use of concrete materials.

## CONCRETE DWELLINGS AND THE FIRE HAZARD.

VARIOUS articles have appeared from time to time in this *Journal* on concrete dwellings, but sufficient emphasis has scarcely been placed on the one great advantage obtained by houses constructed of concrete over timber-built erections, in that they are practically fire resisting and immune from the conflagration hazard. True, the advantage has been pointed out in connection with individual buildings, but the immense possibilities of danger to the community if timber-built houses were allowed to be erected in any number in any locality appear to have been overlooked.

Records would seem to show that fire is not much more likely to originate in a timber-built building than in one substantially built of brick or concrete, but, having originated, there is a far greater possibility and probability of the individual loss being far heavier ; and, in addition, there is the serious likelihood of its spreading from one building to another, especially if the majority of the buildings in the immediate vicinity are of such construction, and the result will be that a serious conflagration will arise, with its concomitant loss of life and national resources.

For as regards the latter it must be remembered that all fire loss is a national loss. Another factor to be considered is that in the event of a fire, even in a building of substantial construction, sparks may be projected therefrom on to a timber-built dwelling and thus set this latter erection alight.

As regards conflagration possibilities, it must be admitted that, in this country, in towns and cities where congestion is the greatest, risk of fire spreading from one house to another—or exposure risk, as it is termed by Fire Preventative Advocates—in the residential area is comparatively slight, as building regulations prohibit the erection of timber-built houses, whilst in outlying rural districts old-fashioned houses of lath and plaster, timber and similar inferior construction, and in many cases with thatched roofs in addition, are not prohibited because in the majority of such instances the buildings stand detached well away from each other or at the most in a row of two or three.

It is suggested that permission should be freely granted for the erection of timber-built houses, but only as a "temporary measure," on account of the present conditions prevailing, due to the late war. Unfortunately, such "temporary measures" belie their names, as once a block of timber-built buildings are erected it is practically certain that no legal power will ever cause them to be demolished. What other laws with regard to dwellings have ever been made retrospective ?

If it is essential to erect dwellings of timber construction at the present time (and notwithstanding all the arguments put forth in their favour there is no doubt that other simple, cheap, more hygienic and non-inflammable materials, such as concrete, can be found) substantial fire walls of fire-resisting material should be erected dividing up the areas covered by the dwellings to prevent any chance of conflagration or holocaust occurring ; but such walls would materially affect the cost of the houses themselves and spoil the amenities of the area. Some may suggest that if there is a space between each building such dangers would be prevented, but what district will stipulate for a minimum of 40 ft. in each direction, provided the buildings are of one floor only in height, with an additional 20 ft. for each extra floor.

It is sometimes said that the rates charged by the fire insurance companies afford a very good guide to the additional hazards due to defective construction, occupation and exposure. In the case of individual timber-built houses but little additional premium is generally charged, but when there is a number of houses of such construction in close proximity to each othere there is a very material increase in the rate, thus indicating that there is in the opinion of the underwriters a material additional risk.

## CONCRETE ROADS AND TRANSPORT COSTS.

Roads are no exception to the rule that a good article must necessarily cost more in the first place than a bad one, but it has been conclusively proved in actual practice that the long life and small maintenance charges of concrete roads largely outweigh their extra initial cost and make them, in the long run, much cheaper than other forms of road construction. A side of the question which has been rather overlooked in the past, however, is the indirect economy which results from good roadways in the lower wear and tear and lower petrol consumption of the vehicles using such roads. This point of view was exhaustively dealt with recently by Mr. H. S. Van Scoyoc in a paper printed in the *Contract Record.*

A series of tests conducted in California to show the pull in pounds per ton required to move a load over various types of roadway are summarised as follows: Concrete surface, 27·6 lb.; concrete base with ⅜-in. asphaltic top dressing, 49·2 lb.; water-bound macadam, 64·3 lb.; gravel, 78·2 lb. All these tests were on level roads in good condition; and, as will be seen, the tractive effort required is by far the lowest on concrete roads.

To test the fuel consumption of petrol-driven vehicles 5 2-ton trucks, loaded to their full capacity, were run repeatedly on different kinds of roads. The average mileage covered per gallon of petrol was as follows: Concrete roads, 11·78 miles; good brick roads, 11·44 miles; fair brick, 9·88 miles; bituminous macadam, 9·48 miles; gravel, 9·39 miles. These tests were carried out in Cleveland, Ohio. A similar series of tests was carried out at the Iowa State College, Good Roads Section, with a truck weighing, with load, nearly eight tons, with the following results in miles per gallon: Monolithic brick, 3·84 miles; concrete, 3·83 miles; bitulithic, 2·86 miles; gravel, 2·66 miles. In this case the brick road is superior to concrete; but this small saving in petrol consumption is outweighed by the excessive cost of maintenance.

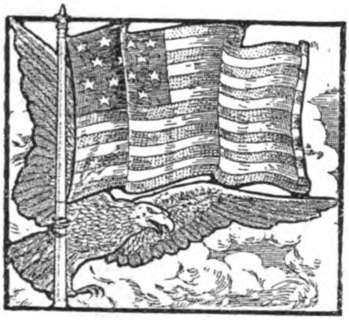
It will be seen from these statistics that, leaving out of account brick roads, a 2-ton lorry, loaded, will travel more than two miles farther per gallon of petrol on a concrete road than on a bituminous macadam road, and that a truck with an overall weight of 8 tons will travel about 33⅓ per cent. farther per gallon on a concrete road than on a bitulithic road. That the value of concrete roads is realised in the United States is shown by the fact that during 1919 a total of 40,453,337 square yards, equivalent to 3,830 miles of roadway 18 ft. wide, was constructed of concrete. Several main roads are at present being reconstructed in concrete in this country; but would it not be in the interests of motor vehicle owners, who contribute so largely to the upkeep of the roads through the rates and the motor tax, to press for the more general adoption of concrete roads, so that some of this outlay, which in the aggregate must amount to many millions per annum, might be recouped by a smaller petrol consumption?

## THE CONCRETE INSTITUTE.

WE are pleased to state that this magazine has been appointed the official journal of the Concrete Institute.

The next few years will witness a great development in the concrete industry in this country, and this will undoubtedly bring with it an extension of the Institute's work. A perusal of the Annual Report published in this issue will give some idea of the importance and scope of that body's operations. One of the effects of the present arrangement will be that, by the monthly notes supplied by the Institute, our readers will be kept regularly informed of the activities of the Institute and of its members.

We take the present opportunity of again drawing attention to the fact that this journal is open to any who have contributions to make on the subject of concrete construction, and any questions will be answered through our inquiry pages.



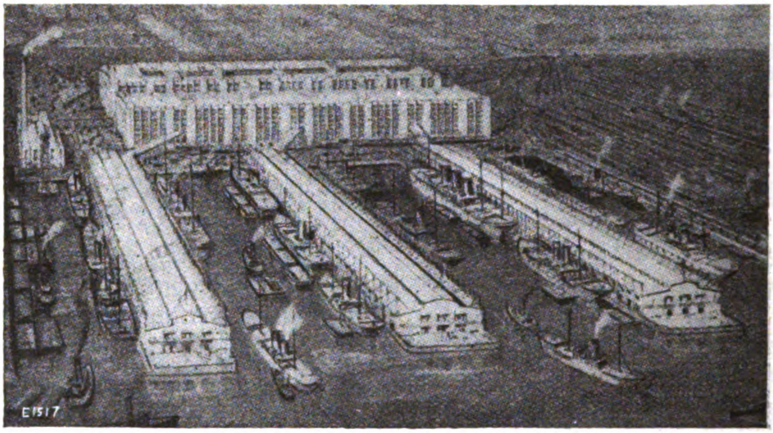
# CONCRETE WORK AT U.S. ARMY SUPPLY BASES.

When the United States entered the war, the experience gained by the other nations proved that preparations had to be carried out on a vast scale, and in that country factories and storehouses of a size which was only recognised as being necessary here after the war had been proceeding for some considerable time were put in hand immediately war was declared. From the constructional engineer's point of view, probably the most interesting operations carried out are the great Army Supply bases at Brooklyn and New Orleans. In both instances the building work is carried out entirely in reinforced concrete, the Brooklyn scheme at a cost of $32,500,000 and that at New Orleans at a cost of $15,000,000. We are indebted to the *American Architect* for the particulars contained in this article, and also for the illustrations. For detailed particulars regarding the New Orleans base we refer our readers to our issue of September, 1919, page 483.

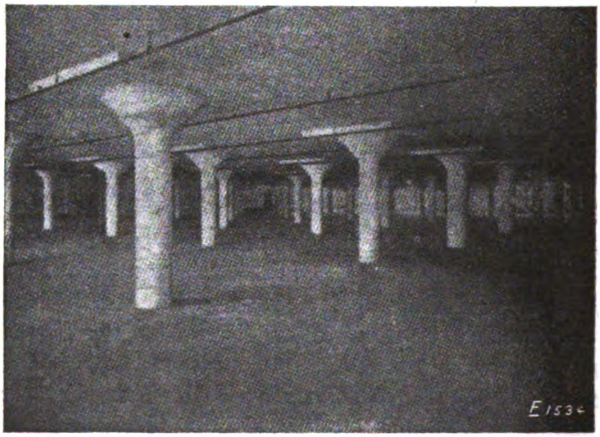
## BROOKLYN SUPPLY BASE.

The Brooklyn Supply Base was carried out to the design of the eminent American architect, Mr. Cass Gilbert, and is stated to be the most efficient, best conceived and expeditiously carried out of all the United States Government's hastily planned schemes. The site fronts on a deep-water channel, and the underlying soil provided excellent conditions for the foundation work. It was orginally intended to provide a total of 6,000,000 sq. ft. of warehouse space, three double-deck piers 150 ft. wide by 1,300 ft. long, one open pier 60 ft. by 1,300 ft., and yard accommodation for approximately 1,300 cars. This would provide storage for 700,000 tons of supplies. By order of the Director of Storage, however, the warehouse space was reduced to 4,000,000 sq. ft. and the railway storage yard increased. The buildings are five in number, *i.e.*, two warehouses, administration building, boiler house and repair shop, all constructed of reinforced concrete.

Warehouse A is 980 ft. long by 200 ft. wide, and consists of eight storeys and a dock storey. The columns are spaced 20 ft. in either direction. The foundations are of the reinforced concrete " spread " type of footings, the design being based on an allowance of three tons per sq. ft. on the subsoil, while, owing to the inferior conditions on part of the site, a continuous mat footing was used over a small portion. The columns are spirally reinforced, and the two-way, girderless type of reinforced concrete construction was used for the floor and roof slabs. All the stairways, elevator shafts and towers are constructed of reinforced concrete. Owing to the large size of the buildings, the question of probable cracks due to expansion and contraction had to be met, and this was provided for by four transverse expansion joints, dividing the columns, floors and roofs. The joints in the slabs are covered with sliding steel plates, and the roof joints with copper plates. With the exception of the main trucking aisles, which are covered with mastic substance, all the floors are finished with granolithic.



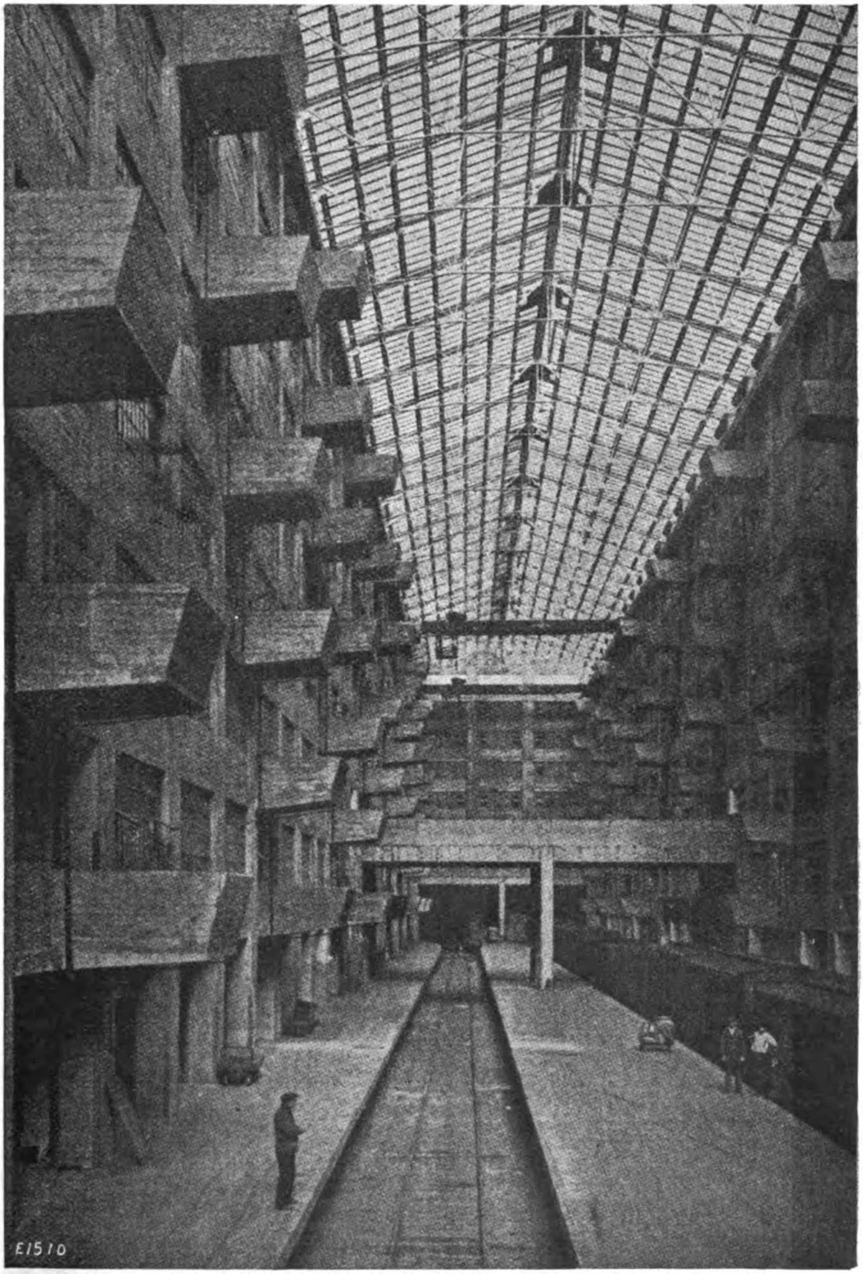
Bird's-eye view of Brooklyn Supply Base.



**Typical floor in Warehouse.**
BROOKLYN SUPPLY BASE.

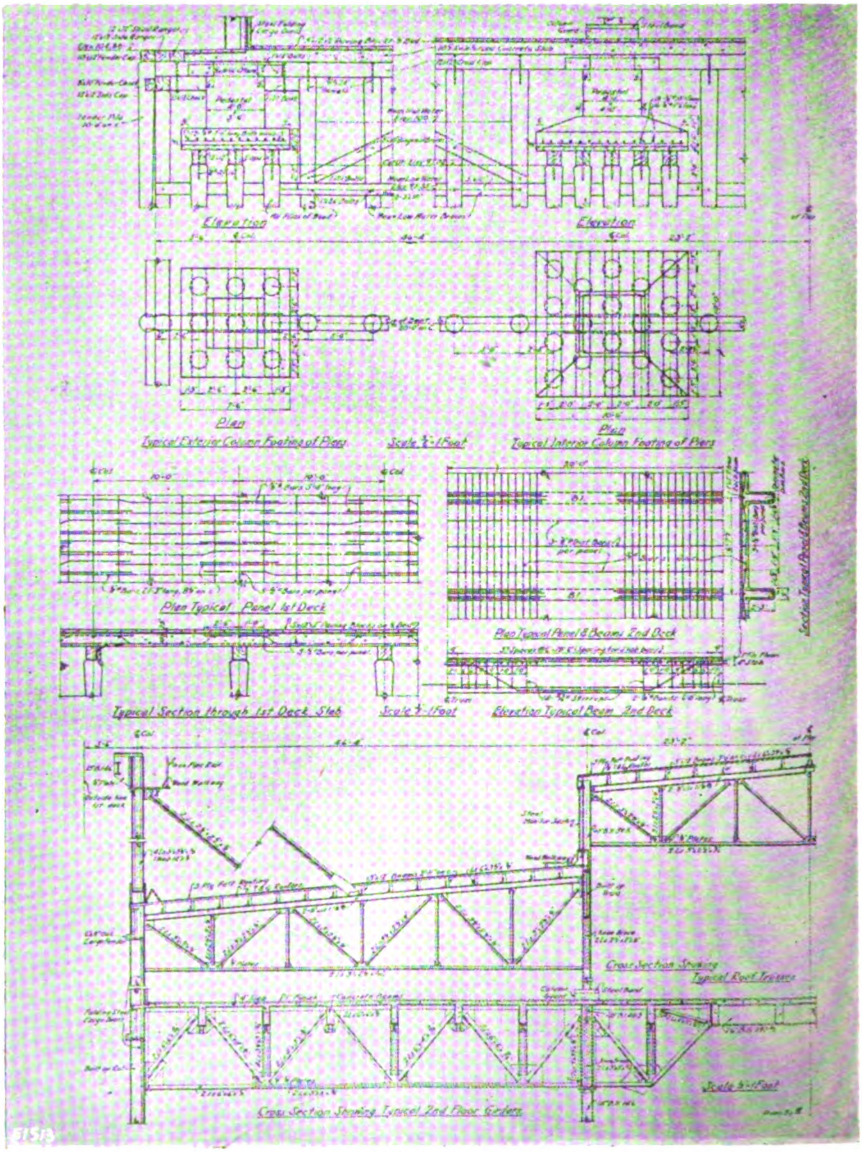
Warehouse B is 980 ft. long by 300 ft. wide, and contains an interior court 66 ft. wide. The height and foundations are similar to Warehouse A, except that concrete piles were used in places to obviate excessive digging.

The boiler house is 137 ft. long by 88 ft. wide, supported on wooden piles loaded to 15 tons each. Up to and including the boiler room floor, the entire structure is of reinforced concrete beam and girder construction, while above that level the interior framing is of structural steel with concrete exterior walls.



ARMY SUPPLY BASE, BROOKLYN.

The Administration Building is 204 ft. long by 54 ft. wide, with four storeys and basement, supported on spread footings. The columns are of reinforced concrete with spiral reinforcement, and the floors are of the beam and girder type.

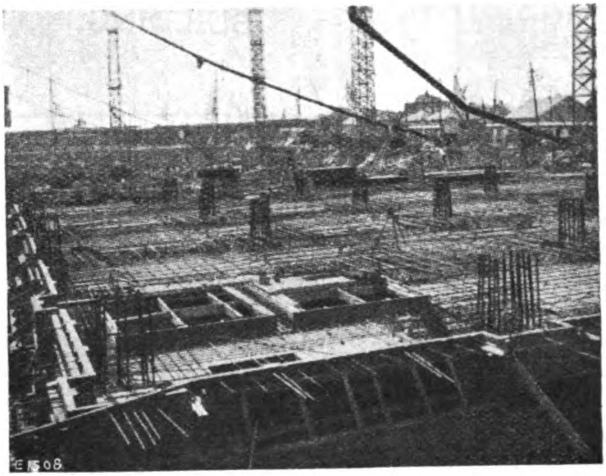

Elevation
Elevation
Plan
Typical Exterior Column Footing of Piers
Scale ½"=1 Foot
Plan
Typical Interior Column Footing of Piers
Plan Typical Panel 1st Deck
Plan Typical Panel & Beams 2nd Deck
Section Typical Panel & Beams 2nd Deck
Typical Section through 1st Deck Slab
Scale ½"=1 Foot
Elevation Typical Beam 2nd Deck
Cross Section Showing Typical Roof Trusses
Cross Section Showing Typical 2nd Floor Girders
Scale ⅛"=1 Foot
51513

Structural details of Piers.
ARMY SUPPLY BASE, BROOKLYN.

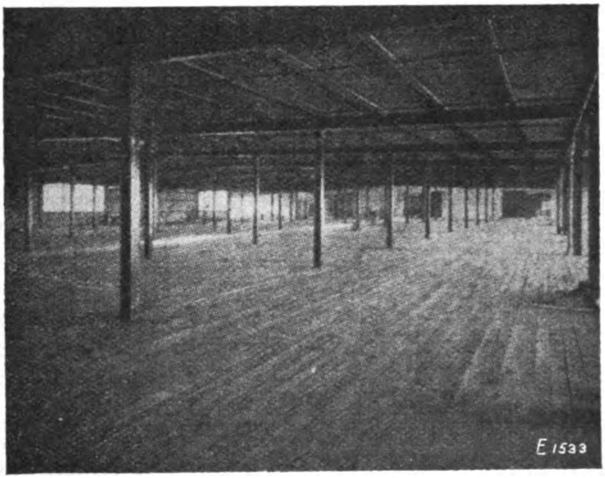
### NEW ORLEANS SUPPLY BASE.

This depot covers an area of 48 acres, and includes three mammoth reinforced concrete warehouses, each 600 ft. long by 140 ft. wide and six storeys in height, and a two-storey steel and pile wharf and wharfhouse 2,000 ft. long and 140 ft. wide, with steel connecting bridges joining the wharfhouse and the warehouses.

The buildings are designed narrow—the width is approximately one-quarter of the length—in order to allow a maximum length of railway platforms. The first storeys in the warehouses are 13 ft. 7 in. high, and the remainder 10 ft. 8 in.



Wharfhouse during constructi n.
New Orleans Base.



Interior view of Wharfhouse.
New Orleans Supply Base.

In the buildings on the wharf the minimum height of the storeys is 17 ft. 6 in. for the lower deck and 11 ft. for the upper deck.

The loading capacity of the various floors in the warehouses are :—1st floor, 400 lb. per sq. ft. ; 2nd floor, 350 lb. ; 3rd, 4th and 6th floors, 250 lb. ; roof, 25 lb.

The structural design of the warehouse buildings is in accordance with the Chicago Building Ordinance.

# CONCRETE COTTAGE BUILDING.

## HOUSING SCHEME AT FOLKESTONE.

MANY features contribute to make the housing scheme at Folkestone, on which work has recently been begun, of particular interest, and it may well be cited as an example to show how much may be effected by an enterprising local authority which makes full use of the resources at its disposal.

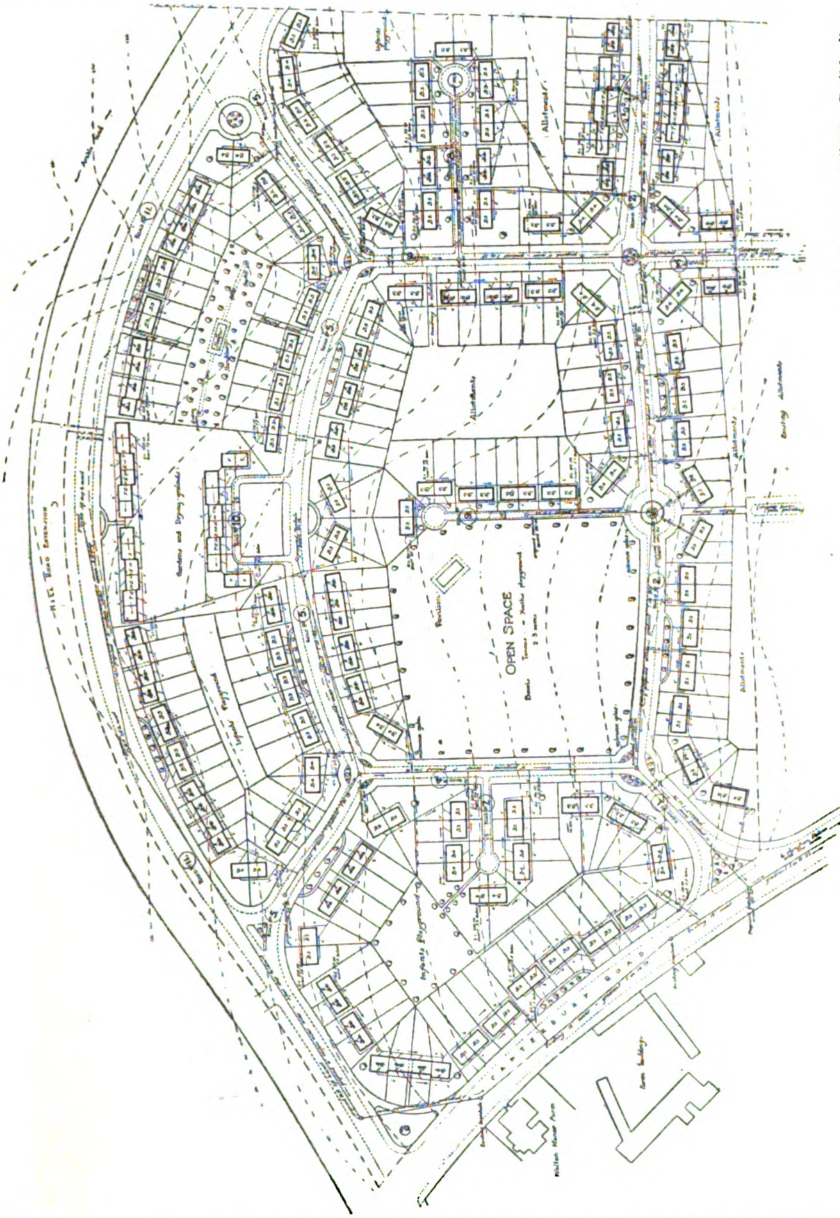
The estate, known as the Canterbury Road site, is beautifully situated at the back of the town, on the gentle southward slope of the downs, which begin to rise more steeply on the north side of Hill Road, which forms the northern boundary of the site. This 100 ft. wide roadway is part of a pre-war town-planning scheme, and when completed it will form a magnificent tree-lined avenue, with double carriageway, footpaths and riding track following the contour of the downs behind the town and linking up on the east with the main Dover road. On the west the site is bounded by the main Canterbury-Folkestone road. The present scheme is for some 250 houses.

Particular attention has been paid in designing the layout to the approaches to the estate; the main approach from the south is along a short 42 ft. road, on whose axis the large playground is diagonally planned with the pavilion at the end of the vista. The scheme has been conceived on generally symmetrical lines, yet at the same time the main roads adhere, for the most part, to the contours. The scheme is liberally equipped, in addition to the large recreation ground of 2 to 3 acres, with allotments, children's playgrounds, drying grounds and the like. On the north of the estate, blocks of tenement dwellings have been planned.

Most of the houses are of the " B " or parlour type, the majority having three bedrooms, while some have two and some four bedrooms each It will be seen from the plans that most of the rooms are of very liberal size, being, indeed, equal to the Ministry of Health's first standards of accommodation, which were in use before that department was reluctantly compelled, owing to exorbitant prices, to effect certain slight reductions.

The interesting feature with regard to the construction of the houses lies in the fact that they are built almost throughout of concrete bricks and roofed with concrete tiles, and that all the bricks and tiles are being manufactured by the borough at their own destructor works.

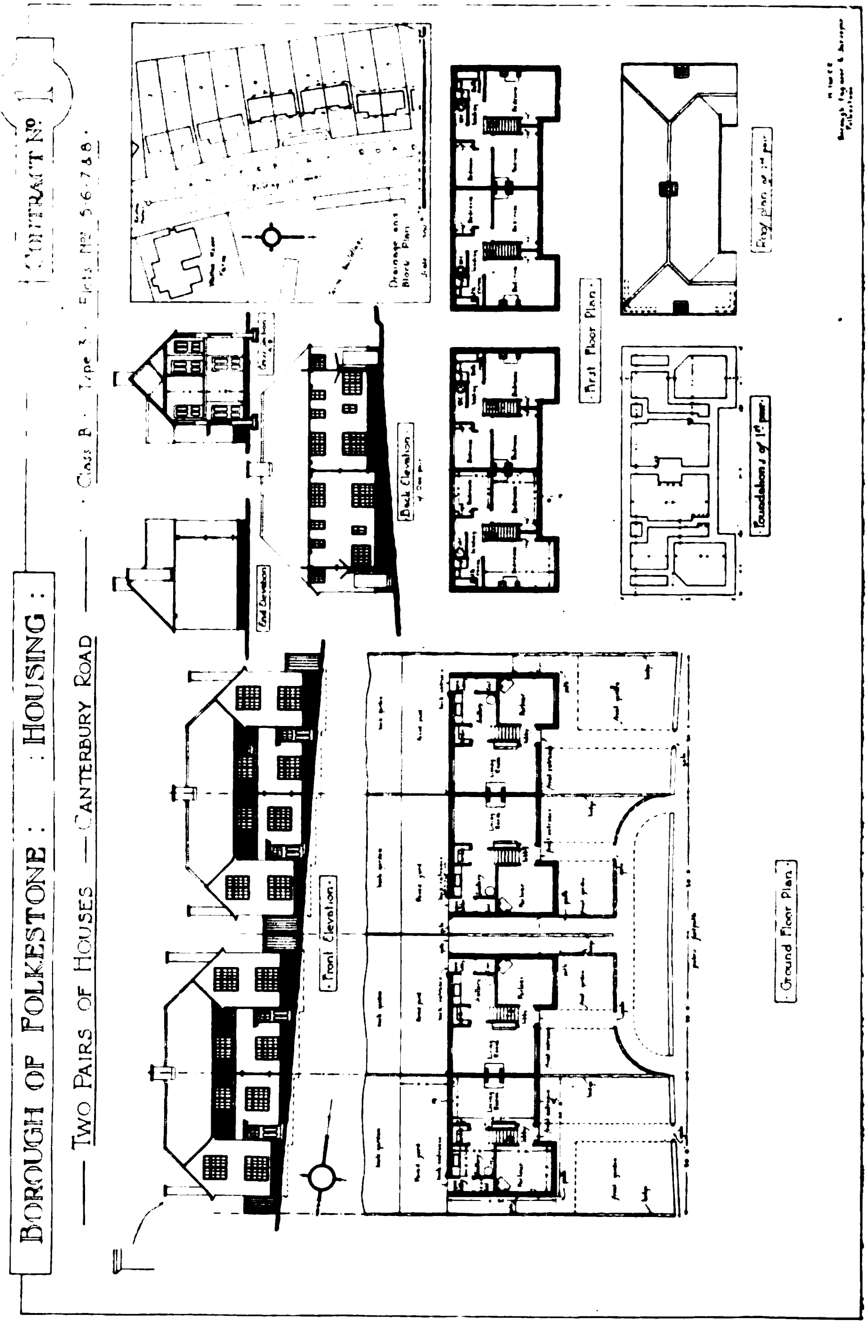
The council are in possession of three " Vickers " brick machines and one " Vickers " tile machine ; but owing to pressure of space never are more than two of the brick machines in simultaneous use. The output from the brick machines is 1,030 bricks per each 8½-hour day, and 70 tiles in the same period. The mixture for the bricks is six parts clinker to one of cement, and for the tiles

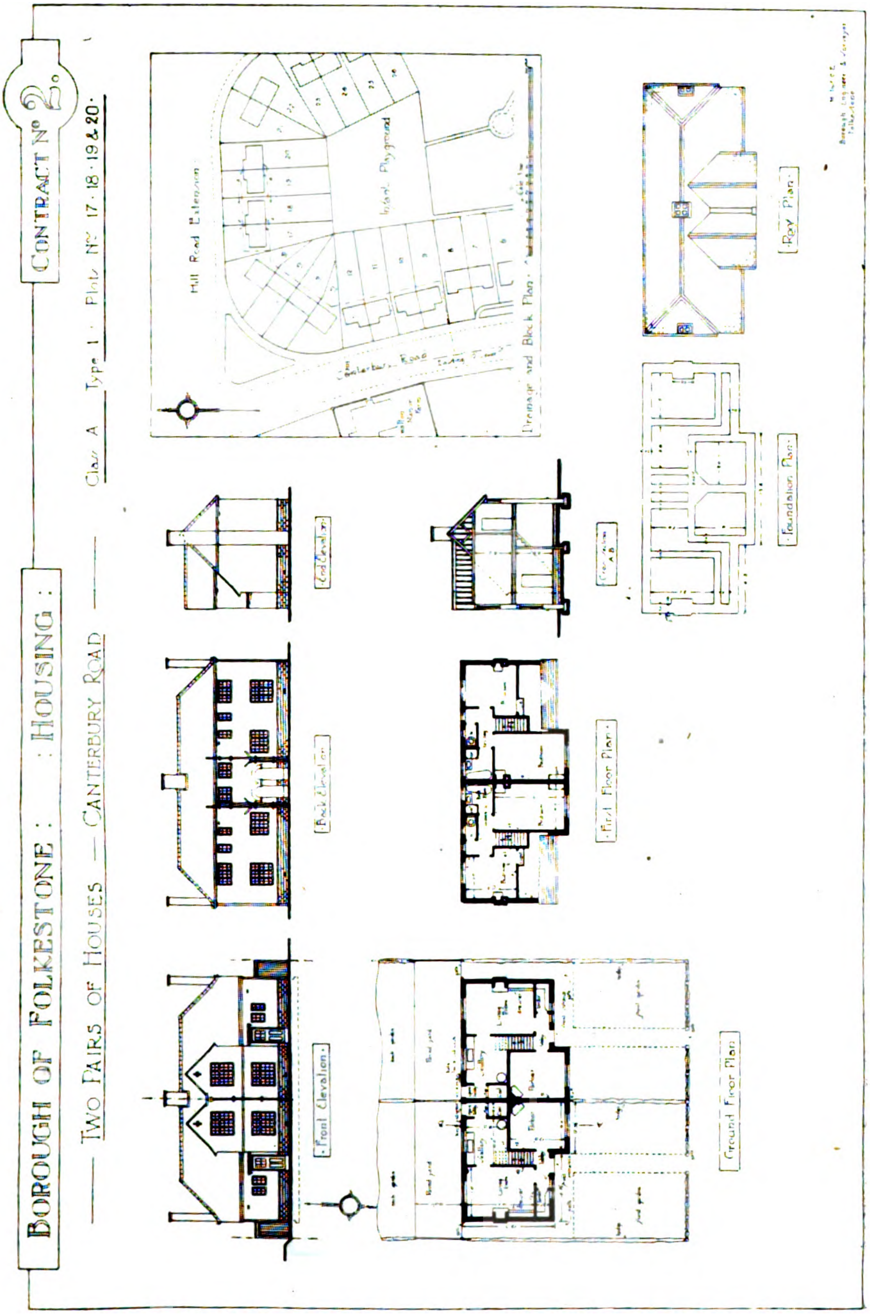


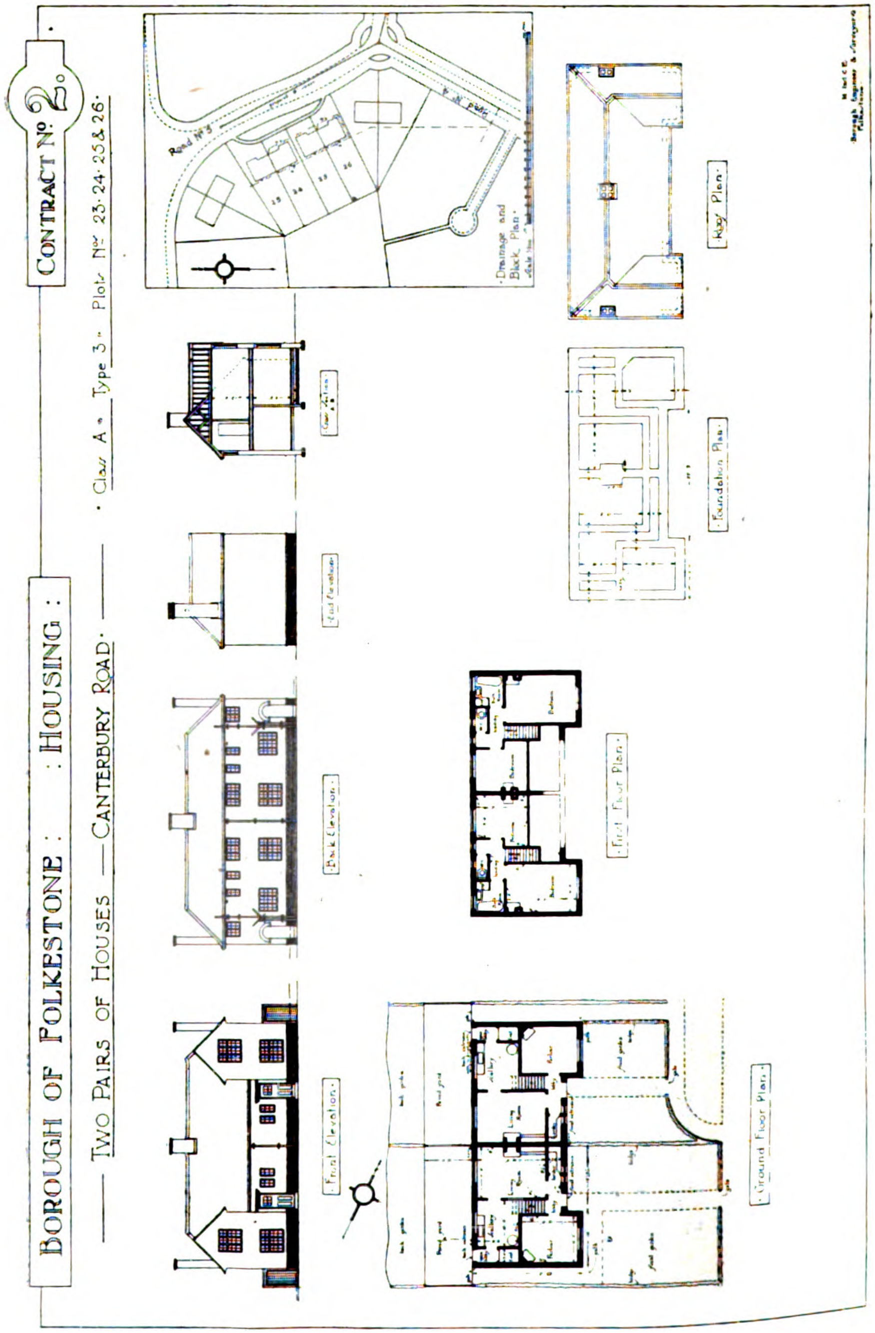
[By courtesy of "The Builder."

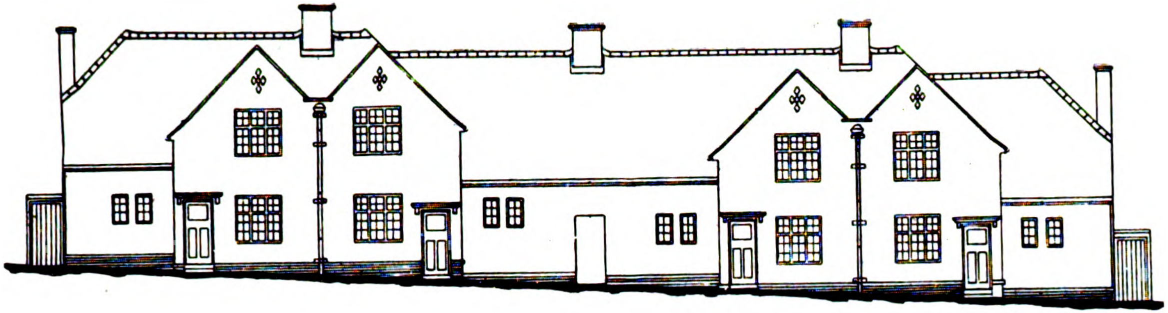
Site Plan.
HOUSING SCHEME AT FOLKESTONE.

three parts clinker and one of cement. The following method is adopted to crush the clinker: it is laid on a good firm bed and a petrol road-roller is run over it a dozen times, this crushes it to the desired size; it is then taken into the shed

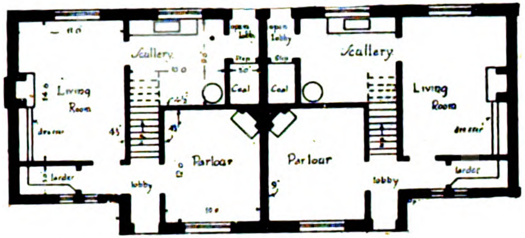

Borough of Folkestone : Housing :
Two Pairs of Houses — Canterbury Road
Class B · Type 3 · Plots Nos 5·6·7 & 8 ·
Contract No 1
Front Elevation
Back Elevation
End Elevation
Cross Section
Drainage and Block Plan
First Floor Plan
Roof plan of 1st pair
Foundations of 1st pair
Ground Floor Plan


Borough of Folkestone : Housing :
Contract No 2.
Two Pairs of Houses — Canterbury Road
Class A · Type 1 · Plots No 17 · 18 · 19 & 20 ·
Hill Road Extension
Infant Playground
Canterbury Road
Drainage and Block Plan
Roof Plan
Foundation Plan
End Elevation
Cross-section A.B
Back Elevation
First Floor Plan
Front Elevation
Ground Floor Plan
Borough Engineer & Surveyor Folkestone

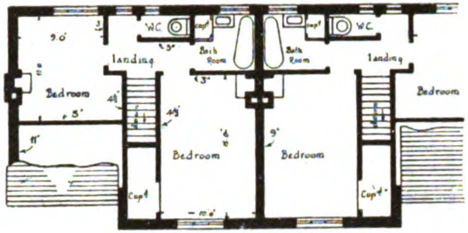

Contract No. 2
Borough of Folkestone : : Housing :
— Two Pairs of Houses — Canterbury Road —
· Class A · Type 3 · Plots Nos 23·24·25 & 26 ·
· Front Elevation ·
· Back Elevation ·
· End Elevation ·
Cross Section A B
· Drainage and Block Plan ·
Road No 3
23
24
25
26
· Roof Plan ·
· Foundation Plan ·
· First Floor Plan ·
· Ground Floor Plan ·



· Front Elevation ·



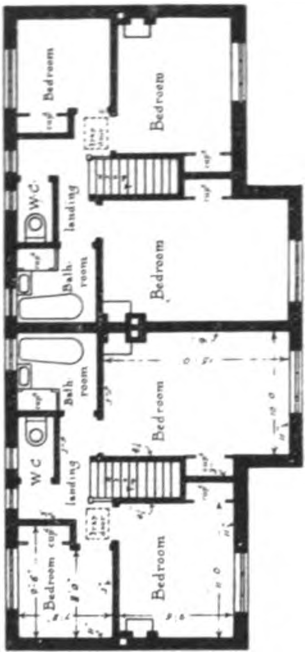
Ground Floor Plan.



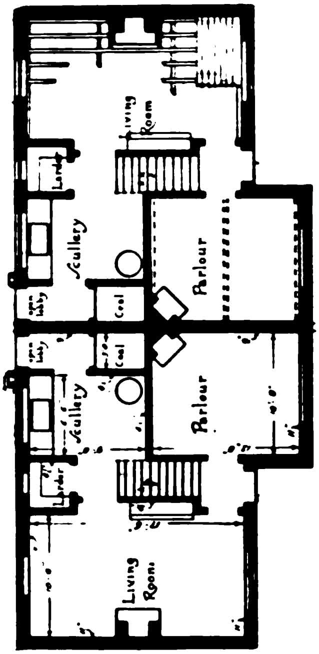
[By courtesy of "The Builder,"

First Floor Plan.

Housing Scheme at Folkestone.

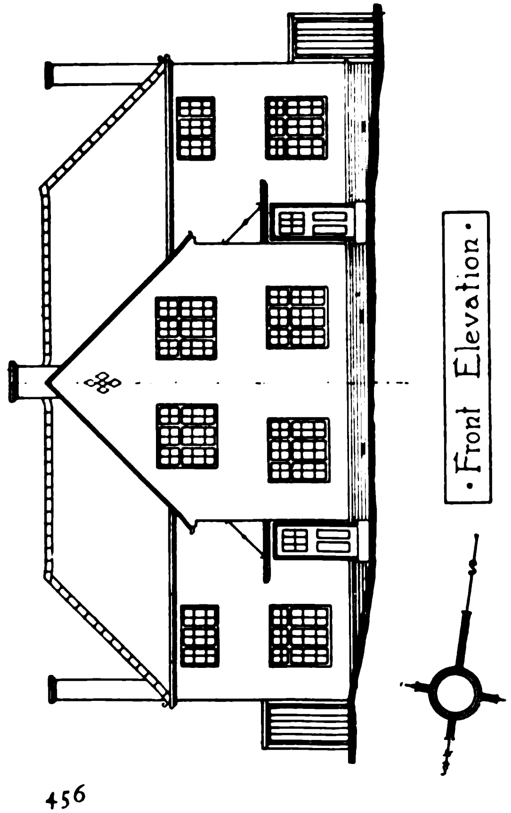


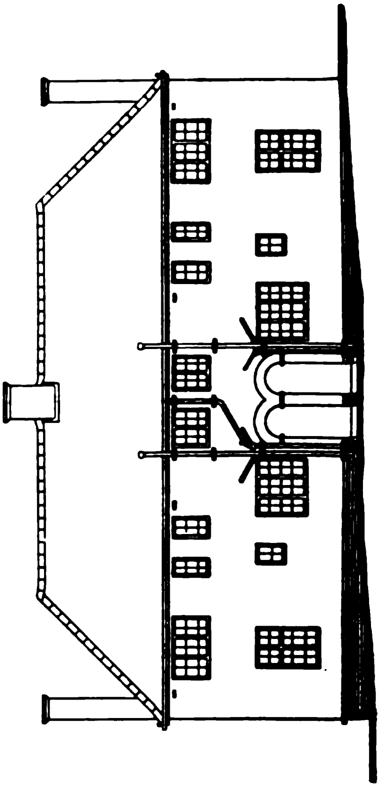
First Floor Plan.



[By courtesy of "The Builder."

Ground Floor Plan.





Back Elevation.

HOUSING SCHEME AT FOLKESTONE.

and screened into four grades—viz., fine, medium, coarse, and large. Fine is used for bricks and tiles; medium, for steps, fence-posts, window-sills and lintels; coarse, for columns and rough work; large, for roads and foundations.

Particular attention is paid to the method of organising the labour, so that the machines receive a constant supply of the raw material and yet no congestion occurs at the machines with the finished articles. Two men are constantly employed mixing for both machines, and there is one man at each machine making. One man is employed at cleaning and greasing the pallets for both bricks and tiles. Two men are employed in taking out, skintling (stacking diagonally), stacking, and also in feeding the mixers with clinker and cement. Some of the bricks and all the tiles are faced with red oxide and cement.

The method of seasoning the bricks and tiles varies somewhat according to the weather. So soon as they come from the machines the bricks and tiles are placed—on their pallets—in wooden racks ranged along the shed, here they remain for about two days, after which time they are taken from the racks and skintled in the open without pallets. In dry weather they are sprinkled with water every other day for the period of a week.

A " Kirk " machine is employed which makes about 100 set pieces per day, lintels and window-sills constituting the bulk of the output. The mixture is three of clinker to one of cement. Two men are employed on this machine. A number of moulds are also used for the manufacture of paving slabs, steps, lintels, columns and fence-posts.

The result of all this work is that the council, in inviting tenders, is in a position to supply the contractors with bricks and tiles, and also lintels, fencing posts, sills, steps, etc., at a considerably lower price than it would be possible to obtain them elsewhere. Thus it is that they are able to have houses of the generous proportions that have already been noted. When it is remembered, furthermore, that the site is by no means a level one, necessitating expense in under-building and excavating; that bathrooms are throughout on the first-floor, entailing expense in plumbing, but additional comfort to the class of tenant to whom the houses will be let; that the bedroom ceilings are almost throughout of the full height; that some of the houses have large porches, an average figure of about £840 per house for the first contract of 24 houses must be considered an extremely reasonable one.

There must be many other borough councils which are in possession of the same facilities as Folkestone; it is to be hoped that they will be moved to emulate this very excellent example of enterprise and resourcefulness. Mention of converting a slag-heap into a row of cottages has often been made, but the phrase has hitherto been used rather in jest than in seriousness. It will now be possible for the inhabitants of Folkestone to see thousands of tons of this unsightly material becoming metamorphosed into group upon group of charming and well-designed houses, and it will be possible at a later date to reproduce photographs showing the work in progress and the completed dwellings.

The design of the layout and the houses, and also the organisation and supervision of the concrete works department has been carried out by the Borough Engineer and Surveyor, Mr. A. E. Nichols, M.Inst.C.E., assisted by Mr. L. Luck.

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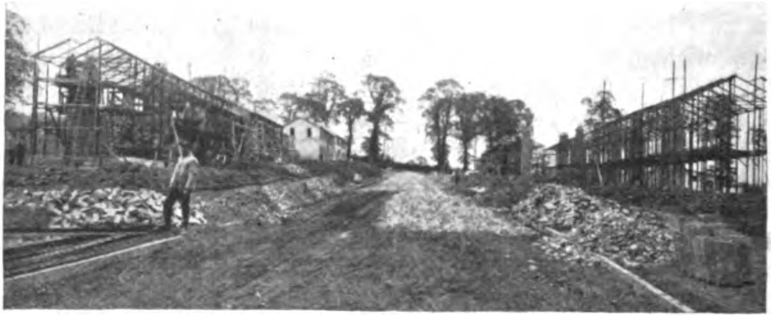
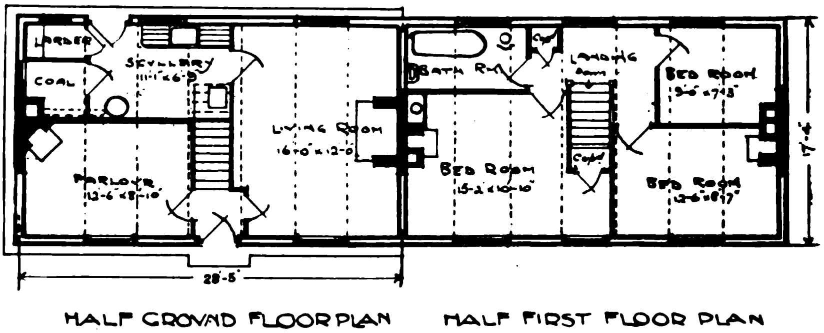
# CONCRETE HOUSES AT BRISTOL.

The housing proposals of the Bristol Corporation are some of the largest in the country, and were of great interest to the delegates to the Inter-Allied Housing and Town Planning Conference, who recently visited the City. The proposals provide for the ultimate erection of some 5,000 houses, the programme for the present year comprising about 1,000 houses. When the schemes were first under consideration, the Housing Committee was faced with the difficulties which confront all prospective building owners, namely, the supply of materials and the shortage of skilled labour. The Ministry of Health intimated a desire that special methods of construction should be adopted, and the Housing Committee eventually decided upon the Dorman Long system for the houses on the Sea Mills site.



Houses in course of construction.



Bristol Housing Scheme.

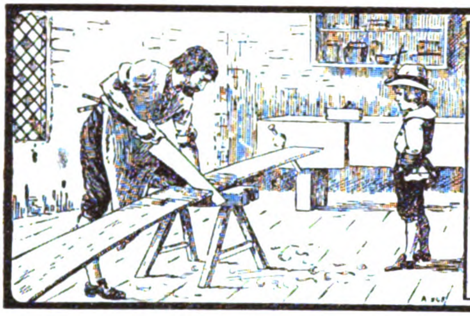
This site, pleasantly overlooking the river between Bristol and Avonmouth, and adjoining the National Park, has an area of 187 acres, and when fully developed will be a self-contained community of more than 10,000 inhabitants. The layout provides accommodation for public buildings, places of amusement, places of worship, schools, shops, recreation grounds and other amenities.

Any tendency towards monotony is avoided in the layout by the absence of regularity in the streets, which are mostly planned in gentle curves, and in the avoidance of straight frontages. Generally, the houses are in pairs, varied with blocks of four.

A feature of the scheme is the rapidity with which the houses are being erected, and although work on the site was only commenced six months ago, several of the houses are now practically ready for occupation. The method of construction is to erect a framework of light steel angle uprights at 4-ft. centres, to the outside of which is fixed "Trussit" corrugated expanded metal. This is then embedded on both sides with cement plaster to form a strong reinforced concrete outer wall. The interior wall is formed of coke-breeze concrete blocks, with a 4-in. air space. The complete wall is thus impervious to rain and moisture from the outside, and the cavity and porous blocks form an adequate safeguard against condensation. The upper floors are of 2-in. concrete slabs reinforced with "Self-Sentering" on steel channels at 4-ft. centres. These channels connect together the front and the rear steel angles, as also do the steel roof trusses, thus securely tying together the whole framework. Slates are used for the roofs, and in order to give variety to the appearance of the houses, the exteriors are finished both smooth and in rough cast.

The method of construction and the house plans have been approved by the Ministry of Health, and the work is being carried out by Messrs. Wm. Cowlin and Sons under the supervision of Mr. L. S. McKenzie, A.M.Inst.C.E., City Engineer, and Mr. C. F. W. Dening, architect

BRISTOL HOUSING SCHEME: A PAIR OF HOUSES.



# PRESSURE OF CONCRETE AGAINST FORMS.

By E. B. SMITH,
*Senior Assistant Testing Engineer, U.S. Bureau of Public Roads.*

*The following is an abstract from a paper read at the last Convention of the American Concrete Institute.—ED.*

THE cost of forms for concrete work constitutes in many cases a rather large percentage of the total cost of the finished structure, and this cost can only be kept low by rationally studied design methods. In so many cases the form is not designed, but is merely guess work on the part of the carpenter, with the result that an unwarranted amount of lumber has been used to prevent failure of spreading. The dimensions and the spacing of the supports and braces should have careful attention to secure sufficient stiffness and ample strength. The sheathing and bracing should be so proportioned as to secure ample stiffness against springing and misalignment. Mere strength without ample stiffness and rigidity is not sufficient for good work.

The proper design of forms cannot be concluded without knowing the lateral and vertical pressures of plastic concrete against the forms. To secure this information the U.S. Bureau of Public Roads has made a few tests which seem to accord in general with the results obtained by others,* but which go further in indicating the values of some of the factors influencing the results. At the present time sufficient data has not been obtained to make any final statement as to the law of pressure of concrete and the effect on each factor, but it is offered now with the desire that it may serve to make a little more definite the usual practice in the design of concrete forms: also that it may suggest a needed field of investigation for other experimenters.

The series of tests were carried out by Mr. W. E. Rosengarten in the laboratory of the research section of the Bureau of Public Roads located at the Arlington Experimental Farm, near Washington. The field tests were made during the construction of the walls and columns of a reinforced concrete building.

Several field tests were run in addition to the laboratory tests during the construction of a reinforced concrete building at the Arlington Farm. The results from these field tests conform favourably with those obtained from the laboratory and are shown in the accompanying table and *Fig.* 2.

TABLE I.

FIELD TEST OF PRESSURE OF CONCRETE AGAINST FORMS.

| Test No. Date. | Mix. | Consistency. | Temperature C. | | Rate of Pouring ft. per hr. | Distance Cell to opposite side of form. | Maximum Pressure Lat. | Head at Max. Press. Lat. | Time at Max. Press. Mins. Lat. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Air. | Water. | | | | | |
| 4–15 | 1 : 2 : 4 | Sloppy | 14° | 13° | 12·0 | 8″ | 1·95 | 3·25 | 17 |
| | | | | | 12·0 | 8″ | 2·45 | 3·25 | 17 |
| 4–17 | 1 : 2 : 4 | ,, | 14° | 15° | 20·0 | 3″ to reinf. | 2·45 stop | 4·62 | 23 |
| | | | | | 20·0 | 18″ | 3·90 pour | 4·62 | 23 |
| 5–26 | 1 : 2 : 4 | ,, | 23° | 23° | 9·0 | 18 × 28″ hole | 2·2 | 3·0 | 20 |
| | | | 23° | 23° | 12·5 | 9–½″ | 1·85 | 2·3 | 11 |
| | | | 23° | 23° | 10·6 | 9–½″ | 1·45 | 2·3 | 13 |

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**Design of Concrete Forms.* R. A. Sherwin, Eng. Record, Feb. 26th, 1916, p. 278.
*Pressure of Concrete on Forms.* F. R. Shunk, Eng. News, Sept. 9th, 1909, p. 283.
*Pressure of Wet Concrete on the Sides of Column Forms.* A. B. McDaniel and N. B. Grover, Eng. News, May 18th, 1916, p. 933.

## SUMMARY OF CONCLUSIONS.

The results shown by the experiments indicate that the fundamental pressure of concrete against the form is about 1 lb. per sq. in. for the first 1 ft. of head. However, this is by no means all that should be said. A study of the results reported by others, and those obtained from this series of tests show that the following factors have an influence upon the pressure, namely: (1) rate of filling the forms; (2) cross-sectional area of the forms; (3) consistency of the concrete; (4) amount of cement in the concrete; (5) temperature of the concrete and the time of set of the cement; and (6) character of the fine and the coarse aggregate.

Sufficient data is not yet available to make final statements as to the law by which each of these factors influence the pressure of the concrete against the form. The results do show that the initial pressure under small heads is equal to the hydrostatic pressure of a liquid having the approximate density or weight of the concrete; that is, approximately 1 lb. per sq. in., or 144 lb. per sq. ft., for the first foot head. As pouring is continued this pressure, however, soon falls below the straight line hydrostatic pressure and the amount of this deviation depends upon one or more of the factors mentioned above.

It is important to notice that the results prove that if filling is continued indefinitely the lateral pressures near the base of the form finally reach a maximum value and then decrease gradually to zero, regardless of the fact that fresh concrete is continually added above. The vertical pressures are in all cases greater than the lateral pressures—they decrease in value after a maximum has been attained, but not to zero. The total weight of the concrete mass in ordinary construction is not supported entirely upon the bottom of the form, but because of the roughness and friction against the sides the planking takes part of the weight or vertical pressure. Of course, for wide and shallow masses of concrete such as floor slabs the vertical pressure is equal to the weight of the concrete.

A summary of the data at hand seems to lead to the following conclusions regarding the effect of the various influencing factors.

(1) The maximum pressure exerted upon the forms increases as the rate of filling increases. At a slow rate of about 1 ft. per hour the pressure is approximately 1 lb. per sq. in., but as the rate increases beyond this value the pressure increases approximately as the 0·3 power of the rate.

(2) Field tests which are made in places where the distance between the form walls differed indicate that the maximum pressures obtained increase slightly with the mass of the concrete when the consistency is wet and sloppy. This conclusion probably does not hold in the case of dry mixes. Reinforcing just inside the form tends to slightly decrease the pressures, but probably this effect would be neglected in determining the final pressures for use in design.

(3) The results show in general that the maximum pressure was increased as the consistency of the concrete was made drier within the limit of workability. This is probably different from what might be expected, but the tests show it to be the case. It is probably due to the fact that under the usual conditions of placing dry concrete, it requires more tamping, which because of its dryness, seems to develop a permanent wedging action between the particles. In the case of wet or sloppy concrete this wedging action does not exist, as we have approximately a static fluid pressure. For low heads the dry concrete (when tamped as usual) will give the greater lateral pressure, but for heads of 4 ft. or more and within the time when initial set becomes an influencing factor, the sloppy mixtures give the greater pressure. The average increase of pressure due to the effect of dry mixtures seems to be 0·3 lb. per sq. in. for each in. decrease in the standard slump test less than a 5 in. slump.

(4) The richness of the mix also affects the maximum pressures obtained. The richer the mix the greater the maximum pressure. The average increase being 0·12 lb. per sq. in. for each per cent. increase in the ratio of the cement to the aggregate beyond 12 per cent.

(5) A decrease in the temperature of the concrete retards the set of the cement, and it is natural to suppose that this is the limiting factor in the maximum pressure obtained, since the pressure increases with the head until the cement takes a sufficient set to begin to support the overlaying concrete. Therefore, as the temperature is reduced and the time of the set of the cement is increased, the height of fill may be increased and thus produce or make possible a higher total pressure. Since the cement begins to set and stiffen in about thirty minutes, the maximum pressure is attained under whatever head of concrete may exist at this time. The value for *H*, the head of concrete, to be used in the formula given below should not be greater than one-half the rate of fill, except where agitation is vigorous and continuous in a sloppy mix, then this ratio may be taken up to three-fourths.

## FORMULA FOR DESIGNING FORM WORK.

An empirical formula giving the lateral pressures required for use in the design or the investigation of the strength of concrete forms, and taking into account the above numerical factors, is

$$P = H^{0.2} . R^{0.3} + 0{\cdot}120 - 0{\cdot}3S$$

*P* being the resultant lateral pressure in lb. per sq. in.; *R*, the rate of fill in feet per hour; *H*, the head of concrete fill; *C*, the per cent. by volume of cement to the combined fine and coarse aggregate; and *S*, the consistency in inches or slump.

The vertical pressure is obtained by adding 0·25 *H* to the value of *P* as found above. Except when the inside distance between the vertical sides of the form is greater than one-half the depth of fill, then the value should be taken as equal to the weight of the concrete.

In the practical application of this formula, as with all formulas, there is abundant opportunity for the exercise of common sense and good judgment. The formula will give pressures somewhat higher than exact values. It shows the effect of continuous and vigorous agitation of the concrete mass only as this is introduced through good judgment in selecting the value of the head of concrete, *H*. For usual conditions *H* may be taken as not greater than one-half of *R*. For ordinary cement in cold weather, or when continuously and well agitated, *H* may be three-fourths of *R*, when the filling is continuous beyond one hour. A second pouring on top of concrete that has been in place for forty-five minutes or more does not add to the pressures already existing at the bottom of the fill.

The values for *C* may be taken as the next higher whole number in the per cent. of cement by volume, as the required accuracy does not justify fractional per cents. Values for *S* may also be taken only as whole numbers since the slump test is not accurate closer than 1 in.

The value of *P* obtained by the formula is the lateral pressure against the form at the lowest point of the fill. Since the pressures are not uniform from top to bottom, but very approximately as the ordinates of a parabola, the centre of pressure or point of resultant pressure may be taken at 0·6 of the height of fill, *H*, from the top.

The following examples may serve to show the use of the above formula:—

*Example I.*—For reinforced mass concrete. Mix to be 1 : 3 : 5; consistency rather sloppy, or 9 in. slump; the rate of fill, *R*, to be 8 ft. per hour. The total height of concrete filled within one hour, 7 ft. Since this concrete is placed from a chute in a large form, and men are continually walking around in it, the value to be chosen for $H$ is 6, or three-fourths of $R$. Then, substituting in the formula

$$P=6^{0.2}8^{0.3}+(0{\cdot}12\times13)-(0{\cdot}3\times9)$$
$$P=1{\cdot}53 \text{ lb. per sq. in.}$$

the vertical pressure $=7$ lb. per sq. in.

*Example II.*—For reinforced concrete column. Mix to be 1 : 2 : 4 ; consistency 8 in. slump ; rate of fill to be 24 ft. per hour. Total height of column and final fill 11 ft. made in one pouring ; since this is done in less than thirty minutes the value for $H$ is 11. Substituting in the formula :

$$P=11^{0.2}24^{0.3}+(0{\cdot}12\times17)-(0{\cdot}3\times8)$$
$$P=3{\cdot}83 \text{ lb. per sq. in.}$$

Vertical pressure $=P+0{\cdot}25\ H=6{\cdot}58$ lb. per sq. in.

*Example III.*—For thin curtain walls and reinforced bulkheads. Mortar mix 1 : 5 ; consistency 8 in. slump ; rate of fill, 20 ft. per hour. Total height of fill in one pouring, 14 ft. ; the value to be selected for $H$ should be 10, since that is the height of fill at 30 minutes when the effect of stiffening and set begins. Substituting, we have :

$$P=10^{0.2}20^{0.3}+(0{\cdot}12\times20)-(0{\cdot}3\times8)$$
$$P=3{\cdot}89 \text{ lb. per sq. in.}$$

Vertical pressure $=P+{\cdot}25H=6{\cdot}39$ lb. per sq. in.

*Example IV.*—For dry mix, mass concrete. Mix to be 1 : 3 : 6 ; consistency, 3 in. slump ; rate of fill, 6 ft. per hour ; distance between sides of form, 3 ft. ; total height of fill within 30 minutes, 4 ft. Thus :

$$P=4^{0.2}6^{0.3}+(0{\cdot}12\times11)-(0{\cdot}3\times3)$$
$$P=2{\cdot}68 \text{ lb. per sq. in.}$$

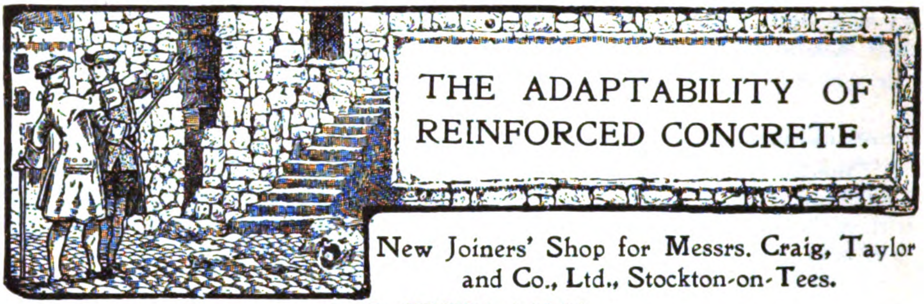
Vertical pressure $=4$ lb. per sq. in.

## MEMORANDUM

**Navy Dirigible Hangar at Lakehurst, N.J.**—The United States Navy is at present building a large hangar for rigid dirigibles, which, it is said, has the largest clear roof area of any structure in that country, and is the largest hangar in the world. Its outside dimensions are 954 ft. in length, and 350 ft. in width, by 200 ft. in height ; with inside dimensions of 803 ft. × 262 ft. × 172 ft. The building is steel frame, resting on concrete piles and footings.

As shown in the details of the footings herewith, there are separate concrete pedestals under each of the three legs of the tower, with steel piles about 10 ft. long embedded in the outer and inner pedestals, the middle one with a lighter bearing requiring no piles. The outer row of piles in each pedestal is driven on a 1 : 4 slope. In addition the three pedestals are tied together by concrete encased channels riveted to the legs of the tower.

The main doors at each end of the structure are somewhat novel in design. The two ends are in duplicate, and each has a two-leaf rolling, self-supporting door approximately the same shape as the arch opening. The doors are of structural steel framing covered with asbestos siding, are electrically operated, aud travel on railway tracks running parallel to the ends of the shed clear beyond the arch, and are designed to take wind-pressure on each side.—*Engineering News Record.*



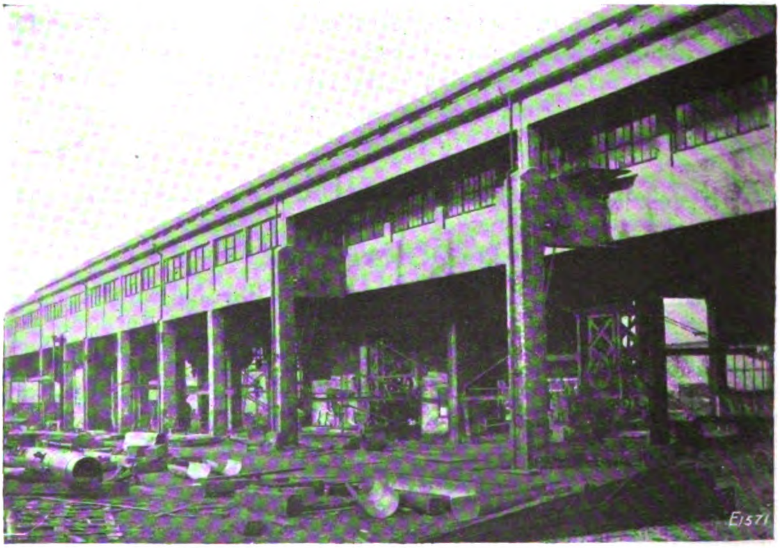
# THE ADAPTABILITY OF REINFORCED CONCRETE.

## New Joiners' Shop for Messrs. Craig, Taylor and Co., Ltd., Stockton-on-Tees.

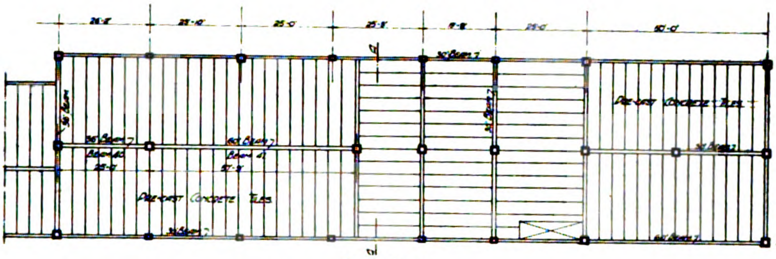
By R. STUBBS, A.M.C.I.

*In erecting the joiners' shop here briefly described a great many difficulties had to be overcome, and owing to the somewhat complicated nature of the work it presents many points of interest to the engineer.—ED.*

THE old joiners' shop in the Stockton-on-Tees shipyard of Messrs. Craig, Taylor and Co., Ltd., was burnt to the ground during the war. Fortunately, however, much of the heavier machinery in the lower storey was not too seriously damaged to allow of its becoming immediately serviceable after a little repairing. This was an important fact, and the main purpose in view in erecting a new joiners' shop was threefold. Firstly, to erect a shop which should be fire resisting. This object was secured by using reinforced concrete construction. Secondly, the shop had to be about 420 ft. long by 50 ft. wide, clear of columns and must be built on the site of the old one and over the existing machinery. For this reason it will be noticed from the part plan given that there is an apparently erratic lay-out of columns. Thirdly, in order that the output should not be unduly diminished, the machinery had to be kept working. There had, therefore, to be as little obstruction as possible and a construction had to be devised that would allow the smallest amount of propping to the reinforced concrete work. This



was very satisfactorily overcome by precasting concrete tiles of various widths and depths ranging from 16 in. to 22 in. according to the spans over which they had to carry. It will be noticed from the part plan that, in some cases, these tiles were as long as 24 ft., where they were made 22 in. deep and 3 ft. 6 in. wide. In order to save timber, the centring of the columns was formed with 4½ in. brick. After the columns had been cast the beams were cast, leaving shoulders, and on these shoulders the tiles already mentioned rested. Not only did this type of construction allow of the least number of props possible, but it also made an extremely light floor, the slabs being as thin as 2½ in.

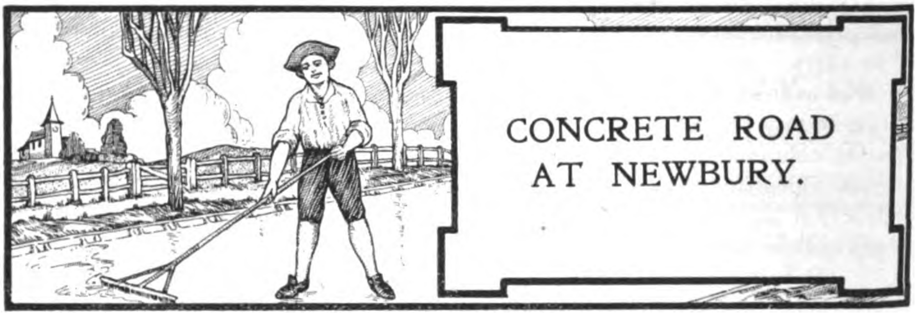


PART PLAN.

Owing to the existing machinery, large span beams were in some cases unavoidable, and in the case of one beam the span had to be 57 ft. 9 in., the depth allowed for this beam being only 5 ft. 0 in. An adjacent beam has only a depth of 3 ft. 0 in.; that is all that was possible, and, in consequence, a heavy reverse moment occurs throughout the length of this beam.

The joiners' shop has a large clear working space, and this can be said to be an ideal shop. The slated roof is constructed on steel trusses spanning on to concrete beams, the shop being lit from the sides and the roof. To the external columns there has been attached hydraulic rivetting machinery and cranes.

The work was designed by the Trussed Concrete Steel Co., Ltd., the reinforcement being on the Kahn system. The builders were Messrs. Blackett & Son.



# CONCRETE ROAD AT NEWBURY.

*Special interest attaches to the road at present being constructed at Newbury, of which some particulars are given below.—ED.*

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ONE more concrete road has been added to the list of those already in existence in the United Kingdom. The road in question is in Northbrook Street, Newbury, the main business street of the town, and, being part of the main road between the Midlands and Southampton, bears a fairly heavy traffic of a general character.

By the courtesy of Mr. S. J. Lee Vincent, A.M.I.C.E., the energetic and capable Borough Surveyor, we are able to furnish our readers with the following particulars.

The length of this street is 440 yards and the width of the roadway, from kerb to kerb, 45 ft., which enables the reconstruction to be carried out in half widths without undue inconvenience.

The concreting was commenced on April 15th and at the time of going to press the whole of one side had been completed, and work is well forward on the other side.

## CONSTRUCTION.

The particulars of construction are as follows :—

Before the work of reconstruction was commenced the gas and water services underneath were carefully renewed. This is a very important procedure, since the chances of expense and annoyance in having to break through portions of the concrete road perhaps soon after it has been constructed are thereby reduced to a minimum.

*Foundation.*—The foundation is that of the original macadam road, and is fairly well consolidated. The surveyor would like to have run the steam roller over it, but on account of the sewer and water mains beneath this course was deemed inadvisable.

The foundation was, however, well watered.

*Course.*—For the concrete road itself the one-course method has been adopted, and the thickness of the slab is 8 in.

*Aggregate and Proportions.*—The materials are mixed in the following way : A measuring box of one-third cu. yd. capacity is employed and this is filled,

Once with 2-in. Clee Hill granite,
Once with 1-in. to ½ in. Clee Hill granite, and
Once with sharp sand and flint grit.

This gives 27 cu. ft. of aggregate to which is added 6 cu. ft. of Portland cement, resulting in a 4½ to 1 mixture. The question was asked whether Clee Hill granite was not unduly costly for the purpose, but Mr. Vincent is taking no risks and will use the best aggregate available.

The materials are mixed by hand, four times in the dry state and five times in the wet, which is a measure of the importance attached by the surveyor to this portion of the work.

*Reinforcement.*—The subsoil here is peat, and it is solely with a view to counteracting its effect upon the road surface that reinforcement is employed. For a like reason the concrete is treated as a slab, and the reinforcement—which is B.R.C. No. 9 fabric—is placed 2½ in. from the under side.

*Joints.*—No transverse joints are provided, the end of each section being finished with a vertical face, and the concrete of the next section butted up against it.

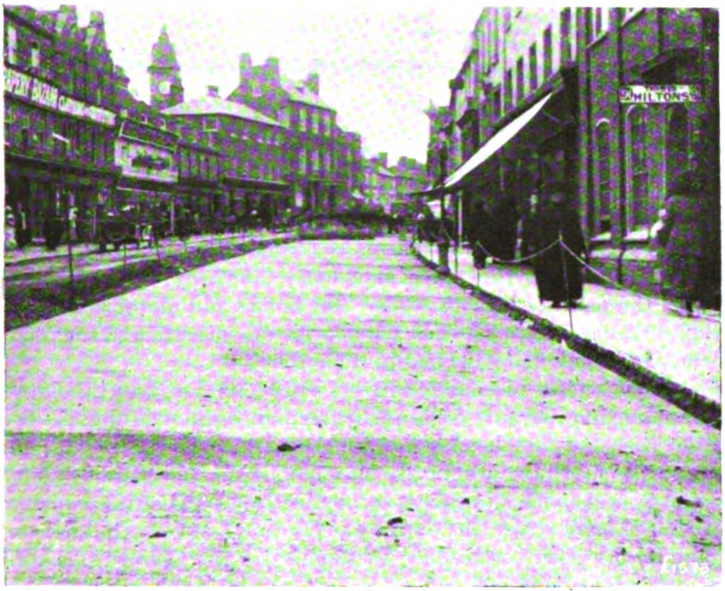


Fig. 1. The Concrete Road in Northbrook Street, Newbury, before being opened to traffic.

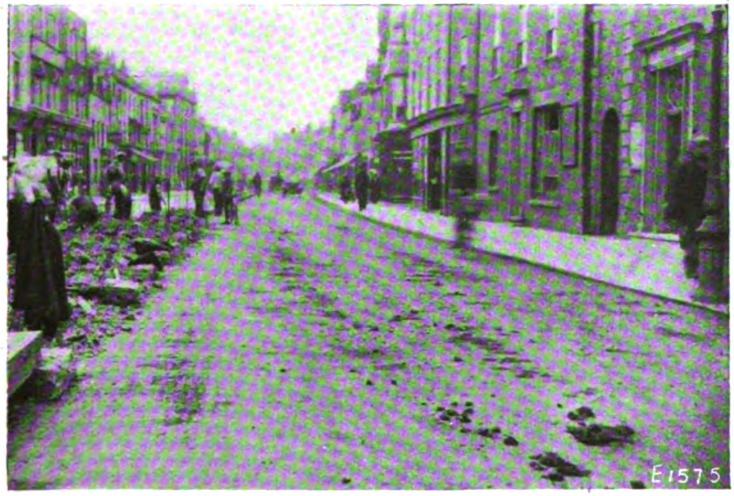


Fig. 2. The Concrete Road in Northbrook Street, Newbury, after being opened to traffic.

At the sides the construction presents a feature which appears to be a novelty. Between the longitudinal edge of the road slab which runs underneath the kerb (to which reference will be made later) and the outer edge of the footpath foundation a space of 2 in. is left. This forms a groove or trench 2 in. wide and 8 in. deep, running under the kerb the whole length of the roadway on each side, so that should there be any lateral expansion in the concrete a 2-in. space is provided in which such movement can take place. This is seen in the section, Fig. 3.

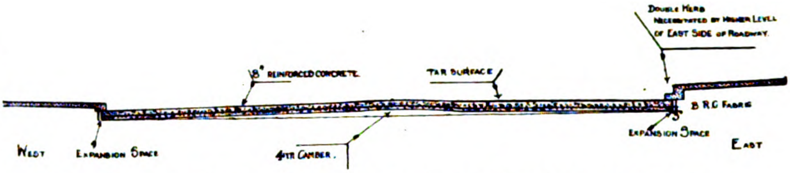


Fig. 3. Transverse Section of the Concrete Road in Northbrook Street, Newbury. On the right is a double kerb, necessitated by the higher level of that side of the street.

*Finish.*—The surface is not floated, but tamped with a cambered iron-shod screed, 2 in. by 9 in. As no machine has been provided for this operation, the tamping has to be done by hand; the effect, however, is the same as that produced by the road-making machine supplied by the Allied Machinery Company. The surface obtained is very fine from the point of view of "grip" for horses and motor vehicles.

*Surfacing.*—Traffic is kept off each portion for one month, and the road is tarred and gritted the day before being opened to the public.

*Camber.*—A fall of 1 in 50 is allowed from centre to side, and the flatness of the finished concrete portion, with its consequent freedom from skidding, is very striking when compared with the camber of the original road.

*Footpaths.*—The footways practically throughout the town are of concrete, laid *in situ* in slabs 6 ft. wide with ½ in. joints formed with wooden strips, which are left in place. Those in the main street, the writer was informed, have been down for 23 years and are in remarkably good condition. In some cases the aggregate is composed of gravel and in others of granite chips.

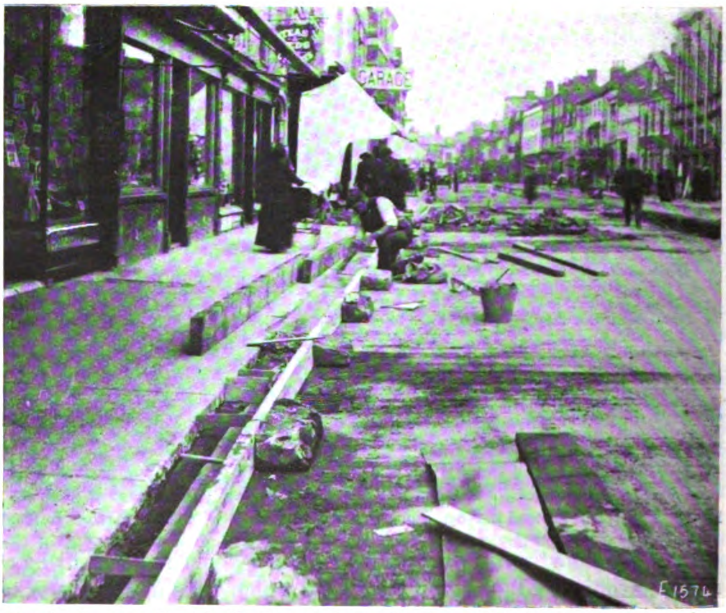


Fig. 4. Concrete Road in Northbrook Street, Newbury. The kerb is here seen under construction. In the foreground the strip of tarred paper will be observed lying in the bottom of the trench. The form is kept in position by spacers on the inside and blocks of stone on the outside.

*Kerbs.*—In Northbrook Street the kerbs (of concrete) are being laid *in situ* with ½-in. joints, as in the case of the footways themselves.

As the original footpaths are being retained, an outer form only is required for the kerb. This is placed in position on the road slab and about four or five inches from the edge, so that the outer portion of the kerb rests upon the roadway itself.

Before placing the concrete for the kerb, a strip of tarred paper is laid in the bottom of the trench formed by the edge of the pavement and the outer form. This strip, which may be seen in Fig. 4, covers over the 2-in. space which has been mentioned above and which acts as a longitudinal joint to the roadway. The concrete is then placed in position up to the level of the footpath, and is finished off with a steel trowel. The appearance of the finished kerb is very neat.

*Cost.*—The total cost cannot yet be given exactly, but is expected to work out at approximately £1 2s. 6d. per super yard. As prices rule to-day this is not high, and in the present instance is regarded as eminently satisfactory. Northbrook Street always has been a bad roadway, and for 20 years prior to the war had cost £300 per annum in maintenance. To-day, if retained as a macadam road, it would cost something like £500 per annum. The concreting of this road will cost somewhere about £5,000, and as the interest on this at, say, 6 per cent., will amount to £300 only, it will be seen at once that Mr. Vincent's contention, that the laying of a new concrete road is a commercial proposition, is borne out by actual figures.

It is anticipated that, when the present road has had time to prove itself, other concrete roads will be laid in the borough.

## THE NEWBURY HOUSING SCHEME.

One notable feature of the Newbury housing scheme is the fact that the houses are actually being built, and another is that they are being built by direct labour. The full scheme comprises 250 houses, of which the 120 constituting the first instalment are well in hand, the buildings being in all stages of erection, while four are occupied. Although the exterior walls of these houses are practically all of brick, the scheme is extremely interesting by reason of the large number of ways in which concrete is being employed, the various articles and structures all being made by the bricklayers on the site when weather conditions are unsuitable for building operations.

The partition walls are of 5 to 1 breeze slabs, and it was surprising to learn that no machine was employed. A large plank floor forms the base-board, and planks are set up on edge to form the moulds, the spaces between the planks being divided up by cross pieces into sections according to the size of slab or block required.

Some idea of the extent of the concrete work will be seen by the following list :— Chimney pots, fence posts, fire kerbs, guard posts, gulley traps, hearths, mantel-pieces, partition slabs, slabs over the doorways, with brackets for same ; soft water tanks, soot doors for copper and flue, straining posts, ventilation bricks, and window heads.

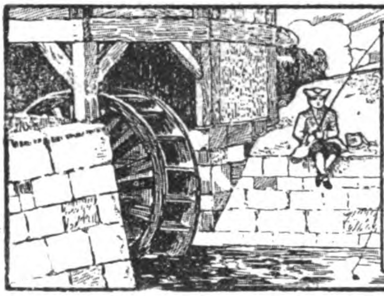
The straining posts are worthy of mention. The post, strut and cross-piece tying the bottom of the strut to the bottom of the post are all cast in one piece, forming a reinforced concrete triangle.

The houses themselves are very artistic in appearance, and it is proposed to treat them, externally, in a variety of ways.

Inside the house the scullery floor is of concrete, as is also the masonry for the copper, the interior being lined with fire brick. The other floors are of wood.

The fire-places are of the latest pattern and all have concrete hearths with concrete kerbs. No grate is used, the fire being laid on the hearth itself. Firebricks are let in at the back and sides of the fireplace, and in that portion of the hearth upon which the fire actually rests. This type of fireplace is said to be most economical in fuel.

These houses, which contain sitting room, living room, scullery and offices downstairs, and three bedrooms, bathroom and W.C. above, are being built at a cost of £700 each, that is to say £200 less than the lowest tender received. The actual cost of the four houses occupied was £2,824. The houses in inside blocks will be let at 10s. 6d. per week, and those in corner blocks at 12s. 6d.



# MASS PRODUCTION OF COTTAGES.

## Pre-cast Reinforced Concrete Houses Erected by Machinery.

By "ANGLO-AUSTRALIAN RESIDENT ENGINEER."

THE development of concrete construction has been very marked during the past ten years, especially in the U.S.A. Some eleven years since, Mr. Thomas A. Edison proposed to build concrete houses in eight hours by pouring a very wet mixture of gravel, sand and cement into iron moulds in the form of a house, and, after the removal of the forms or moulds, leave standing a complete house with a fine surface, plain or ornamental, in one solid piece, including the cellar, partitions, floors, roof, stairs, mantels, verandah—in fact, everything except the windows and doors. Probably had not Mr. Edison forgotten the necessary reinforcement to resist tensile stress he would not have proposed to solve the housing problem.

Those of us who have passed from general building construction and constructional engineering and know from many years' practical experience the value of pre-cast reinforced concrete, and what can be done in the way of economy and rapid construction by unskilled labour and the use of cranes and concrete mixers, under expert management and skilled supervision, can see clearly that concrete properly handled must supersede the slow, costly and indifferent old-time method of building for the bulk of the houses required in reconstruction.

There is no need for a building panic or the disorganisation of the whole of the building industry for the production of the necessary houses; moreover, it is impossible to obtain the required houses by our antiquated method of building construction. We can only muddle along in the old way and build houses by hand labour in small numbers at twice the cost of their true value, and thus impoverish the community. Standardising and pre-casting the component parts of houses, and erecting large reinforced concrete units by crane power, as on public works contracts, is undoubtedly the most rapid and economical method of building construction, and will largely meet the requirements of Europe for houses.

A method of building artistic houses and bungalows by the street or mile, which requires no skilled labour until after the roofs are covered in, and then very little, should appeal to all who are interested in the speedy production of houses. We have much to learn in this country about the more modern methods of building construction and up-to-date machinery, tools and appliances, for dealing rapidly and economically with concrete. Concrete mixing stages, wheel barrows and running planks are a dead loss to the contractor. A stationary mixer is also a money waster for anything but foundations and mass concrete.

When buying sand, ballast and cement delivered on the job it costs no more to have it dumped about the building near where it is to be deposited as concrete than it does to dump it in a heap near a stationary mixer and wheel it to the place of deposit, thereby adding cost to every barrowload. Three feet cube up to ¼ yd. portable mixers, which can be easily moved from place to place with a petrol engine on the same carriage, will put life into a job and save money.

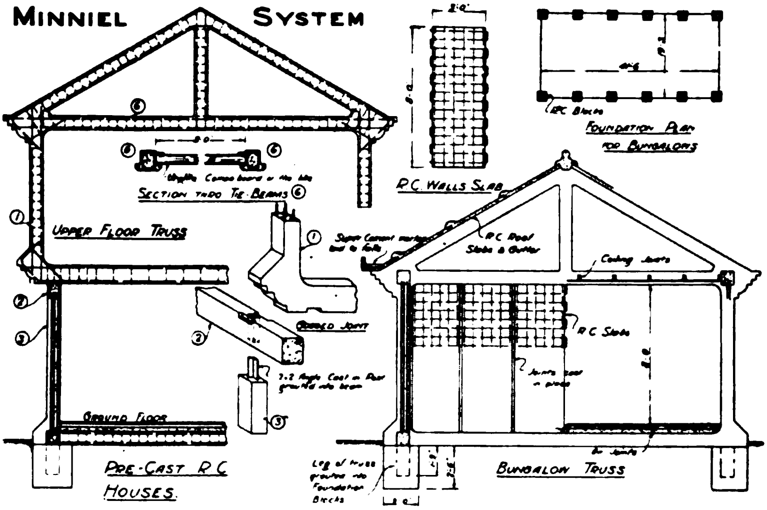
Pre-casting posts, beams and slabs has entirely revolutionised building in fine concrete. There is plenty of room for development in this form of construction, and an unlimited variety of very pretty houses and bungalows may be constructed at a very low cost compared with brick. I know a borough council which has recently placed a contract for a large number of pre-cast reinforced concrete houses on the "Minniel" system at £602 per house; the same plans are to be used as supplied to the tenderers for the houses in brick-work—the lowest tender for which was £1,363 per house. There are twelve different kinds of houses under this contract. The prime cost estimate for "B" class houses, parlour type, including royalties, was, in February last, £602 per house. With the increased price of steel and cement, £26 must be added to the original estimate —viz.: £628, plus recent increase in rate of wages. These houses were to be built at the price mentioned. It can be done by good organisation, efficient management and up-to-date machinery. The contractors have secured their own sand and gravel pits, road tractors, wagons and haulage plant, and use power screens, crushers and cranes. For the building operations they require no skilled labour until after the roofs are covered in, and very little then. It is intended to carry out this job entirely by ex-Service men, and other contracts will be carried out on similar lines, as these young ex-Service men are most anxious and willing to learn and to become skilled in pre-casting and erecting houses by machinery.

Pre-casting with face exposed for surface treatment has made possible concrete finishes that a few years ago would have been thought impossible. The rough-casting can be done on the flat while the slabs are in the casting frames and while the body of the slab is wet, making a superior job. Plastering can be cast on the slab and incorporated in one body, instead of the usual vertical three-coat, render, float and set work. The casting-frames form a screed, and a perfectly true face may be obtained with very little skill and no previous experience of plastering if an American long-handled trowel is used.

Those who have experienced the ease with which large blocks and beams of concrete up to twenty tons are placed by cranes and native labour will look upon the largest units required for cottage and house construction in the form of pre-cast trusses weighing 3 tons as a very light job and easily handled, but the old-time man, used to 8 lb. or 9 lb. bricks laid by hand and trowel, and inexperienced in this class of work marvels to see the frame of floors, walls and roof erected in two or three days, which in brick-work in a similar number of months would be considered a quick job As compared with dock and harbour work, wharves and jetties, where over-water roads have to be provided, and the sea and the tides obeyed, the mass production of cottages in pre-cast reinforced units by public works engineer in conjunction with the architect presents no difficulties whatever.

In considering the matter of concrete in the construction of the home, there never was, and probably never will be again, such a time as now. There is no reasonable doubt about the great economy of the pre-cast truss constructed house. It does not crumble or decay ; it grows stronger with age ; once a good house of concrete, always a good house of concrete ; the roof is as durable as the walls of the building. Of what other building material can such a statement be truthfully made ?

The time has come when in general a house can be built of pre-cast reinforced concrete at a lower first cost than of less durable materials. It is undeniably cheaper in upkeep and, in mass production, less expensive than a house of timber. Furthermore it is cleaner, free from vermin, warmer in winter and cooler in summer; it is proof against fire, time and weather ; and, under the directions of the proper designer, concrete may be used with beautiful effects unobtainable in other materials. When construction companies are well equipped to handle concrete properly, then in the average locality we shall see a mild reaction in high-priced cottage building.



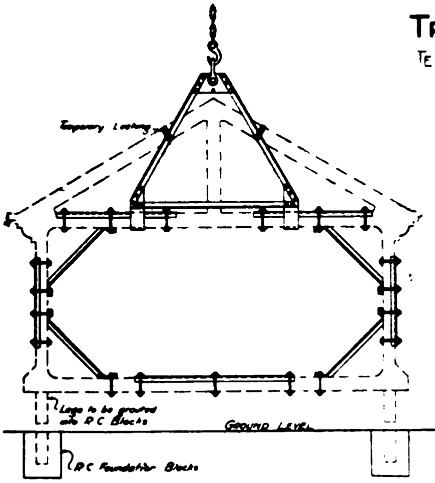
One of the greatest criticisms made on concrete construction in general is that its appearance is monotonous ; this is not the appearance of the concrete surfaces which pre-casting has made possible, either by exposing the aggregates by removing the grey film of cement, sprinkling with sparkling mica, black and white marble chippings, crushed granite, colouring the facing mixture with burnt and raw oxides of iron, white Portland cement, beach shingle, Kentish rag stone chippings, natural grey rough-cast, pebble dash on various coloured grounds, or colouring the face after the job is completed with Cabot's stucco stains, which are made in practically any shade desired.

The illustrations serve to show the " Minniel " system of pre-casting and large truss units. Six trusses for the frame of floor, walls and roof of a bungalow with a frontage of 43 ft.

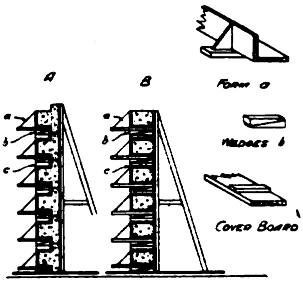
*Foundation.*—The foundation consists of twelve blocks of concrete, in the centre of which sinkings are cast 1 ft. 9 in. in depth, and in diameter ½ in. larger than the leg of the truss to allow for grouting after the trusses are erected and stayed.

The complete frame of the building including roof can be erected in from two to three hours. The trusses are cast one above another in tiers of six, and a period of twenty days should be allowed before erection.

*Floors.*—The floors are formed by pre-cast slabs into which rows of inverted wire nails are inserted at the time of casting, the pointed ends projecting 1½ in. Battens 3 in. by 1½ in. are driven upon the points of the nails and form flooring joists to which the flooring boards are nailed in the usual manner.



TRUSS SLING AND TEMPORARY STIFFENERS.



CASTING TRUSSES IN TIERS OF SIX
A SECTION THROUGH TIE BEAMS
B SECTION THROUGH FLOOR BEAMS

*Ventilating Floors.*—A space of ½ in. is allowed between the edges of the slabs when laying same for an air current under the boarded floors.

*Ceilings.*—The ceilings are of asbestos-cement sheets, compo-board or the like. Off-sets are cast upon the tie-beams upon which the ceiling sheets can be placed by two men as fast as they are handed up to them from below. If the trusses are suitably placed, the sheets may be stock size and require no cutting or fitting. Ceiling joists of 4 in. by 2 in. are placed above the ceiling sheets and supported by the off-sets, 3 in. by 1 in. battens, two to each bay of joists, are nailed to the upper edge of joists to act as binders. The sheets are nailed to the joists, and the joint covered with a 3in. by ⅝ in. moulded or chamfered cover fillet.

*Walls.*—The walls are 6 in. thick, including a 2 in. cavity, and consist of an external slab 2 in. in thickness of impervious cement concrete reinforced with self-woven drawn-steel mesh which projects 1½ in. from the edges of the slabs in the form of stables. The slabs are the full height of the storey. The projecting reinforcement from one member overlaps that of the adjacent slab or post, and is laced transversely after erection with wire or steel hooping, making a monolithic building. The internal wall slabs are of breeze or clinker concrete, and are connected with the external slabs by a nib which projects 2 in. from the cavity face of the external slabs; into the centre of the nibs, at the time of casting, galvanised wire ties are inserted.

*Beams.*—In buildings of the bungalow or one-storey type, the plinth and stringer beams are cast *in situ*, also the ridging.

*Roof.*—The roof is covered with slabs which are in length from centre to centre of the roof trusses; the face is of coloured cement, and may be of tile pattern or otherwise.

*Joints.*—All joints are cast *in situ.*

*Buildings of Two Storeys.*—Six trusses form the complete frame of the upper floor, walls and roof of a pair of houses. The connection between the stringer beams and the upper floor trusses consists of cogged joints grouted in with cement. The first truss erected is stay with steel diagonal braces; the remainder of the trusses are linked to the first truss erected. The upper storey or any part thereof may overhang the lower.

*Eaves Gutter.*—The eaves gutter is formed by the upturned edge of the lower range of roofing slabs; the bottom of the gutter floated with cement mortar laid to falls.

With good organisation and efficient management these houses of mushroom growth and everlasting stability can be cast and erected by ex-Service men without any previous experience of old-time building methods; very few skilled men are required.

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## MEMORANDUM.

**Viaduct-Building in Chicago.**—An article in the *Engineering World*, by W. T. Christine, on "Building the Chicago Union Station Terminal," describes the method adopted for constructing the necessary viaducts.

In planning the viaducts they were made the full width of the streets. Caissons for the viaducts are sunk at points corresponding to the gutter on the streets; and the sidewalks are cantilevered out. The caissons are carried down to hard pan, about 60 ft. below city datum. The caissons, which have a bell formed on the bottom, are filled with 1 : 2 : 4 concrete. On top of the caissons is placed a reinforced concrete girder, which supports three steel columns. To these is attached a cross girder, which cantilevers out the full width of the street, including the sidewalk. The floor of the viaduct is supported by longitudinal stringers of steel, which are riveted to the cross-girder.

Subsequently forms are built up surrounding the columns, a false floor is put in below the street longitudinal supports, steel reinforcement is secured to both columns and steelwork of the bridge, which then is incased in concrete. The floor of the viaduct is formed of a reinforced concrete slab, which takes in the longitudinal beams – the girders; in fact, all steel parts of the structure are incased in the concrete. On the concrete slab of the roadway will be placed wood paving blocks.

On the sidewalk part of the viaduct a concrete slab will form the walk, and on each side will be a concrete parapet wall, 4 ft. high, the back of which is built monolithic to the floor, of reinforced concrete construction, and the inside is made of pre-moulded concrete.

# THE CONCRETE INSTITUTE.

MONTHLY NOTES.

By the SECRETARY.

**Visit of The Concrete Institute to Tilbury River Jetty on Tuesday, 22nd June, 1920.**

By the kind consent of Mr. C. R. S. Kirkpatrick, chief engineer of the Port of London Authority, a small party, representing the Concrete Institute, visited the new river jetty at Tilbury, on Tuesday, 22nd June, 1920.

Those present included: Messrs. E. Lawrence Hall, R. Graham Keevill, A. E. Marshall, J. Petrie, O.B.E., R. W. Vawdrey, Lawson S. White, M. E. Yeatman, and the Secretary, Capt. P. L. Marks, together with Messrs. Bradbeer, Nicholson and Capt. J. Wynne-Harley.

Mr. E. Fiander Etchells (President), Major J. E. Franck (Vice-President) and Mr. H. J. Deane (Chief Assistant Engineer, Port of London Authority), had hoped to be present, but were prevented by other engagements.

The party was met at Tilbury Station by Mr. Chandler, one of the staff at the new works. On arrival at the offices, Mr. Nolans (resident engineer for the new works), met the party, and guided them over the jetty, explaining the principal points of interest.

The work consists of a main jetty, 1,000 ft. long by 50 ft. wide, parallel to the shore, and a curved viaduct 900 ft. long carrying the railways from the main jetty to the shore, where they are connected up through the Dock lines with the general railway system of the country.

The main jetty is a double-decked structure, the space between the two decks forming a transit shed. The lower deck is about 6 ft. above high water level. Access to the transit shed is provided by hatchways through the upper deck. The whole of this structure is carried on cylinders sunk generally two feet into the ballast which occurs about 40 ft. below Ordnance datum. Clusters of piles are driven in the cylinders which are then filled up with concrete. Electric cranes of 60 ft. radius to lift two tons are provided on the river side of the jetty for handling the cargoes of ships; cranes of 40 ft. radius are provided on the landward side of the jetty to deal with the loading of barges, for which accommodation is provided at the back of the jetty. There are two lines of rails with cross-over roads on the upper deck.

The main feature of the approach viaduct is a reinforced concrete bowstring bridge; this is necessary to provide access for barges to the back of the jetty. As the bridge (whose span is 100 ft.) is on the skew the bowstrings are "staggered." Each bowstring weighs about 150 tons. There are over 18 tons of reinforcing steel in each bowstring. The dead weight of decking carried by each girder is about a further 150 tons. Part of the viaduct is built on cylinders in the same manner as the main jetty, but as the shore is approached, the construction is changed to piles.

Afterwards Mr. Nolans conducted the party to inspect the Reinforced Concrete Dock Gates, erected a short time since at the docks, and this proved also to be a work of much interest. Mr. H. J. Deane has kindly promised to embody some notes about these gates in a Paper to be read before the Concrete Institute, during the session 1920-21, and has already presented some interesting photographs of these works.

A vote of thanks to Mr. Nolans and his assistants was proposed by Mr. Yeatman and seconded by Capt P. L. Marks (Secretary), and carried with acclamation.

By the courtesy of Sir Frank Baines, C.B.E., M.V.O., of H.M. Office of Works, a visit of the Concrete Institute is being arranged to the Pensions Offices at Acton. The date of this visit will be Saturday, September 11th, 1920, at 3 p.m. Further particulars will be issued in due course.

# ANNUAL GENERAL MEETING.

*The Annual Meeting of the Concrete Institute took place on May 27th at Denison House, Vauxhall Bridge Road, S.W., when the Report of the Council for the 1919-20 Session was presented. An abstract from this Report is given below.—ED.*

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## REPORT OF THE COUNCIL—SESSION 1919-20.

**Membership.**—The membership of the Institute at the end of April, 1920, was 1,075. A chart accompanies the Report showing the growth in membership from the Institute's foundation to April 30th, 1920.

The Institute continues in a healthy condition, the accessions to its ranks showing an appreciable increase, notwithstanding the higher standard of attainments now necessary for membership.

**Educational Lectures.**—The Council decided to recommence its courses of educational lectures which formerly proved such a welcome feature. The first series was consequently arranged for during February, March and April of this year, and, as stated below, the meetings were well attended and much appreciated.

**Bronze Medal.**—As a result of a ballot among members of Council, the bronze medal for the best paper read in the 1918-19 session was awarded to Dr. P. G. H. Boswell, D.Sc., for his paper entitled " The Geology of Aggregates and Sands."

**Visits of Inspection.**—It has been found possible now to recommence the arrangement of visits of inspection, and besides the one referred to later under the Reinforced Concrete Shipbuilding Sub-Committee, the following two visits were arranged :—

Wednesday, March 24th, 1920.—By the kind permission of Mr. Gordon Selfridge, the new works now in progress at the Oxford Street premises were visited.

Wednesday, April 21st, 1920.—By the kind invitation of Mr. H. Greville Montgomery, an official visit was paid to the International Building Trades Exhibition at Olympia.

**Examinations.**—The scheme of examinations approved by the Institute some years ago, but hitherto not put into force, has at last been allowed to materialise, the first examination for Graduateship and Associate-Membership having taken place on May 13th and 14th, 1920.

It has been suggested for consideration that the Institute should start examinations in local centres at home and abroad, but this, together with the question of the establishment of local branches, whilst under consideration, is not yet advanced to such a stage as to be able to be commented upon further in the present report.

**Research.**—With regard to research, the Science Committee summoned an important Conference for January 5th, 1920, so that the Committee and the various laboratories concerned might consider the result accruing from a recent series of comparative crushing tests upon concrete cubes. There were such great discrepancies shown in the results that it was felt necessary to investigate the cause or causes ; and as a result of the deliberations of the Conference it was agreed to institute a fresh series of comparative crushing tests, where there should be as much co-ordination as possible, and where the conditions should be throughout equal, so that the cause of such discrepancies might be discovered, and it was anticipated that under the newer conditions the discrepancies would be less striking.

Another matter of research now proposed to be undertaken by the Science Committee is an investigation into the microscopy of cement. A certain amount of preliminary work has already been done in this respect, and it is hoped that it will be possible to furnish useful particulars upon this research in the next report.

**High Tension Steel.**—The Sub-Committee appointed to consider the use of high tension steels for reinforced concrete work has continued its sessions, and the tests upon the specimens prepared were carried out in January and February, 1920, at the

Manchester College of Technology under the direct supervision of some of the members of this Committee. Consequent on this it was decided that the Chairman, Mr. H. Kempton Dyson, should be empowered to read a paper dealing with these tests preparatory to a report being issued on the subject. It is well to make clear that these tests were merely of a preliminary nature, and that the Sub-Committee will continue its sessions with a view to subsequent tests being arranged.

**Concrete Shipbuilding.**—The Sub-Committee to consider the subject of the use of reinforced concrete in shipbuilding drew up its report, which was accepted by the Council and ordered to be printed in the Transactions. In connection with this subject it is of interest to add that the reinforced concrete boat *Faith* being in dock last summer, an opportunity was taken to arrange a visit of inspection.

**Science Committee.**—A Sub-Committee was appointed in 1919 by the Science Committee to consider suitable amendments to the British Standards Specification for Cement, and when the labours of this Committee were completed the Council submitted the proposed amendments to the British Engineering Standards Association, which agreed to them substantially.

**Standard Specification for Reinforced Concrete Work.**—Another Sub-Committee was approved by the Council for the purpose of bringing up to date the proposed Standard Specification for Reinforced Concrete Work. Several meetings were held, and eventually the Council approved that in its amended form it should be again printed for the consideration of the Science Committee preliminary to its being issued to the public.

**Literature.**—Early in 1920 the Council decided to appoint a new Standing Committee to be known as the Literature Standing Committee, which would absorb the duties of the Editorial Committee, and also deal with the sessional programme, with papers submitted, and with library matters. Mr. E. Fiander Etchells was chosen as the first Chairman ; the full list of this Committee as first constituted will be found in the subjoined list.

In succession to Mr. H. D. Searles-Wood, F.R.I.B.A., etc., whose term of office as President expired in May, 1920, Mr. E. Fiander Etchells, A.M.Inst.C.E., A.M.I.Mech.E., Hon. A.R.I.B.A., etc., has been chosen by vote to succeed him for the period 1920–1922. As the result of a vote Major J. Ernest Franck, F.R.I.B.A., has been elected a Vice-President. Mr. Searles-Wood will continue to devote his services to the Council as Past President.

## COMMITTEES.

The Committees appointed for the Session by the Council were as under :—

### THE FINANCE AND GENERAL PURPOSES COMMITTEE.

Chairman, Major J. Ernest Franck, F.R.I.B.A., etc. ; Vice-Chairman, Sir Henry Tanner, C.B. I.S.O., etc.

Professor Henry Adams, M.Inst.C.E., etc. ; Mr. H. Kempton Dyson ; Mr. E. Fiander Etchells, F.Phys.Soc., etc ; Mr Charles F. Marsh, M.Inst.C.E. ; Mr. H. D. Searles-Wood, F.R.I.B.A., M.R.San.I. (President) ; Mr. H. J. Tingle, M.Inst.C.E., etc. ; Mr. E. P. Wells, J.P., etc. ; Mr. F. E. Wentworth-Sheilds, M.Inst.C.E., etc. ; Mr. G. C. Workman, M.S.E. ; Mr. M. E. Yeatman, M.A. (Cantab.), M.Inst.C.E., etc ; *ex-officio*—Chairmen of Standing Committees.

### THE SCIENCE STANDING COMMITTEE.

Chairman, Dr. J. S. Owens, F.G.S., M.Inst.C.E., etc. ; Vice-Chairman, Mr. D. B. Butler, Assoc. M.Inst.C.E., etc ; Hon. Secretary, Mr. Ewart S. Andrews, B.Sc. (Eng.).

Professor Henry Adams, M.Inst.C.E., etc. ; Mr. H. K. G. Bamber, J.P., F.C.S. ; Professor T. Hudson Beare, B.A., B.Sc., M.Inst.C.E. ; Mr. S. Bylander ; Professor J. D. Cormack, C.M.G., C.B.E., D.Sc., etc. ; Mr. H. J. Deane, M.Inst.C.E. ; Mr. H. Kempton Dyson ; Mr. E. Fiander Etchells, F.Phys.Soc., M.Math.Assoc., etc. ; Dr. Oscar Faber, O.B.E., D.Sc., etc. ; Major J. Ernest Franck, F.R.I.B.A., M.R.San.I ; Mr. H. C. Johnson ; Mr. Charles F. Marsh, M.Inst.C.E., M.Am.Soc.C.E. ; Mr. W. G. Perkins (District Surveyor for Holborn) ; Mr. A. R. Sage ; Mr. H. D. Searles-Wood, F.R.I.B.A., M.R.San.I. (President); Mr. R. H. Harry Stanger, Assoc.M.Inst.C.E.; Mr. R. W. Vawdrey, B.A., Assoc.M.Inst.C.E.; Mr. E. P. Wells, J.P., P.P.C.I.; Mr. F. E. Wentworth-Sheilds, M.Inst.C.E.; Mr. M. E. Yeatman, M.A. (Cantab.), M.Inst.C.E., etc.

### THE REINFORCED CONCRETE PRACTICE STANDING COMMITTEE.

Chairman and Hon. Sec., Mr. R. W. Vawdrey, B.A., Assoc.M.Inst.C.E.; Vice-Chairman, Mr. Ewart S. Andrews, B.Sc.(Eng.).

Professor Henry Adams, M.Inst.C.E., P.P.C.I.; Mr. S. Bylander, J.I.E.; Mr. J. S. E. de Vesian, M.I.Mech.E.; Mr. H. Kempton Dyson; Dr. Oscar Faber, O.B.E., D.Sc.; Major J. Petrie, O.B.E., F.Perm.Way Inst.; Mr. F. Purton, F.S.E.; Major L. H. Rugg, R.E., Assoc.M.Inst C.E.; Mr. A. R. Sage; Mr. A. Alban H. Scott, M.S.A.; Mr. Archibald Scott, M.B.E., A.R.I.B.A.; Mr. H. D. Searles-Wood, F.R.I.B.A., etc.; Mr. T. B. Shore, M.S.E.; Mr. J. M. Theobald, F.S.I.; Mr. T. A. Watson, Assoc.M.Inst.C.E.; Mr. E. P. Wells, J.P., P.P.C.I.; Mr. F. E. Wentworth-Sheilds, M.Inst.C.E.; Mr. G. C. Workman, M.S.E.; Mr. M.E. Yeatman, M.A. (Cantab.), M.Inst.C.E., etc.

### THE PARLIAMENTARY STANDING COMMITTEE.

Chairman, Major J. Ernest Franck, F.R.I.B.A., M.R.San.I.; Vice-Chairman, Mr. Osborn C. Hills, F.R.I.B.A. (District Surveyor for Strand); Hon. Secretary, Mr. Percy J. Black (District Surveyor for Wandsworth East).

Professor Henry Adams, M.Inst.C.E.; Mr. W. E. A. Brown, A.R.I.B.A.; Mr. E. Fiander Etchells, F.Phys.Soc.; Mr. W. G. Perkins (District Surveyor for Holborn); Sir Henry Tanner, C.B., I.S.O., etc.; Mr. E. P. Wells, J.P., etc.; Mr. G. C. Workman, M.S.E.

### THE LITERATURE STANDING COMMITTEE.

Chairman, Mr. E. F. Etchells, A.M.Inst.C.E., etc.

Mr. W. A. Green, M.A.; Mr. Charles F. Marsh, M.Inst.C.E.; Mr. F. Purton, F.S.E.

### THE BOARD OF EXAMINERS (THE EXECUTIVE COMMITTEE).

Chairman, Professor Henry Adams, M.Inst.C.E.

Mr. S. Bylander, J.I.E.; Mr. E. Fiander Etchells, M.Math.Assoc., etc.; Mr. W. G. Perkins (District Surveyor for Holborn); Mr. H. D. Searles-Wood, F.R.I.B.A., M.R.San.I. (President); Mr. E. P. Wells, J.P., P.P.C.I.; Mr. M. E. Yeatman, M.A. (Cantab.) M.Inst.C.E., M.Am.Soc.C.E.

The Council regrets to record the deaths of the following from its ranks:—Mr. M. W. Clark, Mr. E. Smith Coldwell, Mr. J. B. Griffith, Mr. A. Bryce Johnston, Mr. R. Vittal Rau, Mr. E. O. Sachs, Mr. A. Thomas, Mr. F. A. V. Vickerman, Dr. Jeme Tien-Yu.

W. N. Olliff-Lea, killed in action 1915 (notice only now received).

### REINFORCED CONCRETE PRACTICE STANDING COMMITTEE.

The Committee are now taking up the question of desirable amendments in the Reinforced Concrete Regulations under the London Building and other Acts. There are various questions before this Committee, some of which are being immediately taken into consideration and others kept before the Committee to be dealt with from time to time as may seem suitable.

## THE ANNUAL MEETING.

The annual general meeting of the Concrete Institute was held at Denison House, Vauxhall Bridge Road, London, on Thursday, May 27th, the retiring President, Mr. H. D. Searles-Wood, taking the chair.

The result of the ballot for Officers and Council for the year 1920–21 resulted as follows:—

President: E. Fiander Etchells, Assoc.M.Inst.C.E., A.M.I.Mech.E., Hon.A.R.I.B.A.

Past Presidents: Prof. Henry Adams, M.Inst.C.E., etc.; H. D. Searles-Wood, F.R.I.B.A., etc.; Sir Henry Tanner, C.B., I.S.O.; F. E. Wentworth-Sheilds, M.Inst.C.E.; E. P. Wells, J.P.

Vice-Presidents: Major J. Ernest Franck, F.R.I.B.A.; Charles F. MarshM.Inst.C.E., M.Am.Soc.E. J. S. Owens, M.D., F.G.S.

Ewart S. Andrews, B.Sc. (Eng.); H. K. G. Bamber, J.P., F.C.S.; Percy J. Black; W. E. A. Brown, A.R.I.B.A.; D. B. Butler, Assoc.M.Inst.C.E.; W. Cyril Cocking; Prof. J. D. Cormack, C.M.G.; H. J. Deane, M.Inst.C.E.; J. S. E. de Vesian; H. Kempton Dyson; Oscar Faber, O.B.E., D.Sc., etc.; W. A. Green, M.A., B.Sc.; Bertram L. Hurst, M.Inst.C.E., etc.; W. J. H. Leverton; Major James Petrie, O.B.E., F.Perm.Way Inst.; F. Purton, F.S.E.; Archibald Scott, A.R.I.B.A.; T. B. Shore, M.S.E.; R. H. H. Stanger, Assoc.M.Inst.C.E.; H. E. Steinberg, Assoc.M.Inst.C.E.; H. J. Tingle, M.Inst.C.E.; R. W. Vawdrey, B.A. (Cantab.); T. A. Watson, Assoc.M.Inst.C.E.; G. C. Workman, M.S.E.; Morgan E. Yeatman, M.A.

The Council's report on the work of the Session was taken as read, and its adoption was agreed to.

It was announced that the Institute medal for the best paper read during the 1918-19 session had been awarded to Dr. P. G. Boswell, D.Sc.

Mr. E. F. Etchells, the new President, was then inducted into the chair, and on his motion, seconded by Sir Henry Tanner, a hearty vote of thanks was accorded the retiring president, Mr. H. D. Searles-Wood.

The President announced the election, as hon. members, of Dr. H. W. Brightmore, of the Ministry of Health, and Mr. G. T. Forrest, recently appointed Superintending Architect for Metropolitan Buildings.

The announcement was also made of the receipt of an invitation from the Société des Ingénieurs Civils de France to join a party of its members on a visit to some of the devastated areas of France.

Major Halstead Best then read a paper on "The Mystery Port, Richborough."

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# THE MYSTERY PORT, RICHBOROUGH.

By Major HALSTEAD BEST, R.E., F.I.S.E., Etc.

*The following is an abstract from a paper read at the annual meeting of the Concrete Institute on May 27th.*

## INTRODUCTION.

"The Mystery Port, Richborough," occupies a site which in early 1916 was a flat marshy piece of land, stretching between Sandwich and Pegwell Bay, its features consisting of:—

Richborough Castle, a ruined Roman castle, having walls over 12 ft. thick, constructed of round boulders and flints, and at about every 4 ft. in height, string courses consisting of two layers of tiles.

Stonar House—an old manor house—afterwards used as an officers' mess.

Sheep grazing on the rough grass were the only indication of life, except when the solemn stillness of the rough marshland was dispersed by the cry of wild fowl or the cawing of rooks, and through all this barren marsh the tortuous River Stour slowly wound its way until arriving at the mud flats of Pegwell Bay.

Yet in less than three years, by something like a wizardlike transformation, this barren, marshy, more or less forgotten, part of England was turned into a great base for transportation, a camp actually housing over 17,000 soldiers, workshops capable of tackling repair works of practically every description, and in addition a home for the naval "Mystery Ships" in the form of a "Mystery Port."

The total area of land acquired at Richborough by the War Department in connection with the several works carried out there, was about 4,000 acres, equal to nearly 6¼ sq. miles, the area actually occupied by docks, wharfs, and camps being over 3¼ sq. miles.

The total strength of the Command at Richborough, on September 15th, 1918, was 15,933 N.C.O.'s and men.

As will be readily understood, the work carried out there was of a very varied nature.

### CAMPS.

In June, 1916, the first Stonar Camp to accommodate 1,000 men was commenced, the men carrying out the work, being housed, some in billets in Sandwich and others on the site of the camp, under canvas.

Workshops were built, slipways constructed, barges re-erected, electric light and power installed, so that by the end of 1916 the I.W. and D., with a strength at Richborough of 6,400 men, had become a port second only in importance on the south-east coast to Folkestone, in addition to becoming the Depot of the I.W. and D.

The permanent camps were five, housing a total number of 12,666 men.

To house this large number of men it required 200 huts, the inside measurements of which varied from 58 ft. 9 in. by 20 ft. 2 in. to 119 ft. 8 in. by 19 ft. 6 in. Practically all the huts were erected with concrete blocks and slabs made in the "Winget" machine, the walls being erected on the pier and panel system. The piers were formed of pier blocks, each 32 in. by 9 in. by 9 in., and erected at 9 ft. 10½ in. centres. The panels were made of panel slabs, each 28½ in. by 9 in. by 2¼ in. Table No. II. gives the cost of manufacture of these blocks at Richborough in 1916, and also the cost of the finished walling.

TABLE II.
STATEMENT OF COST OF STANDARD WINGET BLOCKS AND SLABS BASED ON INFORMATION OBTAINED AT RICHBOROUGH.

| Type. | Size. | Weight of each in lb. | Contents in ft. cube. | No. per pull. | Net cost per block based on material costing 8d. per cu. ft. and labour per pull, 6½d. | Cost of labour, rate per yd. super including mortar and materials. | Net cost per yd. super of work laid. | Add for plastering and rough casting per sq. yd. |
|---|---|---|---|---|---|---|---|---|
| | | | | | d. | s. d. | s. d. | s. d. |
| Panel Slab ... | 28½″×9″×2¼″ | 40 | ·34 | 3 | 4·91 | 1 1 | 3 2 | 2 3 |
| Partition Slab ... | 32″×9″×4½″ | 84 | ·75 | 2 | 9·44 | 1 5½ | 5 0 | 2 5 |
| Pier Block ... | 32″×9″×9″ | 140 | 1·08 | 1 | 15·41 | 1 10 | 7 8 | 2 3 |
| Half Pier Block ... | 16″×9″×9″ | 70 | ·55 | 2 | 7·7 | 1 5 | 7 3 | 2 3 |
| Quoin Block ... | 32″×16″×9″ | 172 | 1·83 | 1 | 21·63 | 1 10 | 8 6 | 2 3 |
| Single Flue Block | 16″×16″×9″ | 98 | ·91 | 2 | 10·79 | 2 2 | 10 4 | 2 3 |
| Double Flue Block | 32″×16″×9″ | 198 | 1·83 | 1 | 21·63 | 2 2 | 10 4 | 2 3 |

These rates were increased for work over 15 ft. above ground.

As a means of readily ascertaining the progress of labour on the various works, a standard concrete hut was adopted as a unit of work, this unit being sub-divided into 100 parts, which were made up as in Table III.

TABLE III.

| | Parts. |
|---|---|
| Excavation .. .. .. .. .. .. | 5 |
| Concrete foundations .. .. .. .. .. | 5 |
| Walling .. .. .. .. .. .. .. | 20 |
| Plastering .. .. .. .. .. .. .. | 5 |
| Concreting floor .. .. .. .. .. .. | 15 |
| Roofing .. .. .. .. .. .. .. | 25 |
| Painting and glazing .. .. .. .. .. | 5 |
| Doors and windows .. .. .. .. .. | 10 |
| Internal fittings .. .. .. .. .. .. | 5 |
| Whitewashing .. .. .. .. .. .. | 3 |
| Electric light .. .. .. .. .. .. | 2 |
| Total .. .. | 100 parts. |

Providing all materials were to hand as required, it was possible, by using Table III., to estimate the approximate length of time required to carry out new buildings, and also to ascertain the progress made, without absorbing a large amount of clerical labour as is sometimes adopted on works of similar magnitude.

During August, 1916, the author made several test cases and found that the net cost of a standard concrete hut, labour and material, worked out at £183 9s.

At the corners of the buildings quoin blocks, L-shaped on plan, were used. The foundation, which was continuous, was of cement concrete, usually about 15 in. wide and 9 in. deep, but the width and depth were generally governed by the nature of the site. The first huts erected in July, 1916, had a sub-floor of concrete, a space of about 15 in. below the floor being provided for ventilating purposes. Later, owing to the scarcity of timber, the joists and boarding were done away with and a single concrete floor having a granolithic finish was provided instead.

In addition to huts, a church, an institute, a large hospital, foundries, machine shops, generating stations, sub-stations, locomotive sheds, and platform walls for loading purposes were all erected of similar blocks, the thickness and dimensions varying according to the nature of the work.

As regards the pier and panel method of concrete block construction adopted in the erection of the various buildings at Richborough, a single thickness of panel slab was not adopted because such construction is as good as or better than a wall of two thicknesses separated by a cavity. The only reason for adopting a single thickness was the fact that such construction is obviously cheaper than a double wall, as it requires less material and labour.

However, as regards the work at Richborough, it is only fair to say that with a single thickness panel, constructed in a sheltered position, and the blocks made of properly graded aggregate and a suitable matrix, there would appear to be no reason for incurring the additional expense in buildings other than those for human habitation.

### THE USE OF CONCRETE.

The various concrete blocks referred to above were made in several yards distributed about the area at Richborough, and set apart as block making yards, having land adjoining for maturing purposes. The cement and aggregate were mixed in varying proportions depending on the class of walling required, and on whether the finished work would be very much exposed. The mixings varied from 1 of cement and 5 of gravel to 1 of cement and 9 of gravel. The concrete mixers were erected on a raised platform so as to deliver the mixing by means of a shoot to a position near the block-making machines. The pallets having been placed in position the mixture in a semi-dry state was well punned in the mould, and the green blocks removed on their pallets to the drying ground. Here the blocks, if the atmosphere was at all dry, were well watered through a fine hose, otherwise an accelerated drying would take place, resulting in the development of visible cracks which would render the blocks liable to be damaged easily during transit to the building site.

Another important feature in the Richborough concrete block yards was the manufacture of reinforced concrete blocks for making pill-box emplacements, over 1,000 complete pill-boxes having been made on August 7th, 1918.

Several water towers were erected of reinforced concrete, the cost of which, based on cement costing 54s. per ton, sand 4s. per cu. yd., gravel 6s. per cu. yd., steel rods at £25 per ton, was for the 40,000 gal. capacity tower £732, the cost per cu. ft. working out as follows :—

| | Per cu. ft. | |
|---|---|---|
| | s. | d. |
| Reinforced concrete in foundations .. .. .. | 2 | 9 |
| Reinforced concrete in structure .. .. .. .. | 3 | 1½ |
| Reinforced concrete in tank .. .. .. .. | 3 | 4¼ |

The unit stresses were :—Steel in tension 16,000 lb. per sq. in., concrete in compression 600 lb. per sq. in., and $m = 15$.

In addition, a large number of reinforced concrete piles were made, most of these being used in the construction of a dock at Grain Island, Yantlet Creek, Isle of Sheppey.

### SEWAGE DISPOSAL.

The scheme was designed to deal with the sewage from the various camps, allowance being made for possible further extensions to a maximum of 25,000 persons.

The water supply was taken at 10 gal. per head; and owing to the flat nature of the land, and therefore the lack of suitable gradients, the sewage gravitates to a central pumping station whence it is pumped to the disposal works, treated, and the effluent discharged into the River Stour. The scheme was designed on the separate system.

### RICHBOROUGH NEW WHARF.

The New Wharf has a straight frontage of 2,213 ft. The sheet piling is of 15 in. by 5 in. joists with clutches, and is continuous. The major portion was delivered in 40 ft. lengths. At plus 2·85 ft. O.D., and at minus 1·75 ft. O.D., two horizontal walings 12 in. square are fixed. On the face of these walings 12 in. square king piles were driven at about 10 ft. 8 in. centres, a number of the piles being continued above wharf level, so as to provide additional means of securing cast-iron bollards, the tops of the piles extending to the under surface of the metal at the top of the bollard. In addition to the two timber walings, two steel walings 12 in. by 5 in. are fixed at plus 7·35 ft. O.D., and plus 11·9 ft. O.D., being secured to the sheet piling by means of two bolts 1 in. diam. and a 9½ in. by 3¾ in. by 1 in. steel washer, holes having been drilled in the web of every fifth steel pile so as to engage the head of the bolt.

The king piles were driven down to an average of 27·50 ft. O.D., and the sheet piling to an average of 22·50 ft. O.D. On the face of each king pile a 12 in. by 4 in. rubbing strip was secured by means of bolts, the heads of which were sunk below the surface of the wood. In order to stiffen the tops of the king piles, especially in view of the fact that bollards had been fixed to several of these, 12 in. square distance pieces were let in flush with the surface of the king piles. On the top of the piling a mass concrete wall was constructed, the base being at plus 4·25 ft. above O.D., and the top flush with the level of the top of the wharf, which was at plus 14·75 ft. O.D., the thickness being 3 ft. 6 in.

Measured to the face of the king piles the wharf was 37 ft. in width and formerly carried two lines of standard gauge tracks, but with the introduction of 5 and 10-ton travelling cranes one track was removed and the other slewed over more towards the centre of the wharf.

The construction of Richborough New Wharf is claimed to be one of the quickest engineering works of its nature ever carried out.

### WHARF MOVEMENT.

After one or two of the cranes, referred to above, had been in operation for a very short time, a horizontal movement in the wharf was reported. This movement was attributed to the fact that the piling had been subjected to greater stresses than were ever intended; and further, owing to the dredged bottom of the wharf having been deepened more than was intended in the first proposal, and the low water level having been considerably lowered owing to the dredging of the outer channel, thereby removing part of the bar, the water level was 2 ft. lower.

The weight of the travelling cranes themselves did not materially affect the stresses in the wharf, therefore the vibration of the wharf, especially at low water, would appear to be responsible for the forward movement that had taken place. Consequently, in order to guard against any more movement, instructions were issued for the cranes to be used only when the water level at the wharf was at or over Ordnance Datum, reducing the period for operating the cranes to about seven hours on each tide. Several calculations were made by various engineers, but owing to the variation of the results due to different mathematical terms representing pressure having been used, the question of whether the wharf was in danger or not was a matter of opinion.

The result of all the observations made was the impossibility of making any reliable mathematical investigations in constructional work of this nature; in every case it was a matter of each engineer's judgment and experience.

With a wharf having a face constructed of such an elastic material as steel piling, any settlement or visible deformation would give ample warning of commencing failure.

### CONCLUSION.

Had our canals and inland waterways, especially those in the South-Eastern part of England, been in anything like a working condition as those in Northern France and Belgium, there is not the slightest doubt but that they would have been an asset to this country during the past war in fighting a country such as Germany, possessing and working such a splendid system of arterial waterways.

Probably as the result of the huge success of the cross-channel barge service the canals of this country will play a more important part as a means of transporting the commercial products of the country.

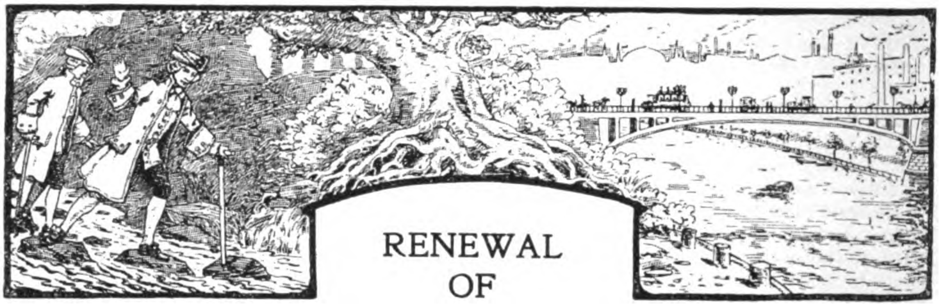
## DISCUSSION.

**Mr. F. E. Wentworth Sheilds**, who proposed a vote of thanks to the author, said that one of the most interesting things in the paper was the system of inter-locking steel piles used for the wharf. The author stated that it had commenced to move, and it appeared that the river in front of it had been dredged and deepened to such an extent that the weight behind the steel piling was too much for it. He would like to see a simple cross section of the wharf wall, and to know how much dredging had been carried out in front of it before it showed signs of moving. He would also like to know what was the nature of the material which was filled in behind the wall. This information was of the greatest importance to all those who had to build maritime works at the different ports throughout the country. He believed that this was one of the first retaining walls which had been built in this country with inter-locking steel pile sheeting. It was a very quick and useful way of constructing such works because the piling penetrated the soil so rapidly, and it had enormous strength. They were expensive, but in this particular case speed was of more importance than economy. This sheet piling was also used at Southampton in connection with the piers for accommodating the train ferry. In that case the large piers of the bridge were surrounded with sheet piling which was driven into the soft mud, and, after the softest of the mud had been taken out, the inside was filled with concrete, and made a most magnificent job, which carried the massive tower in connection with the train ferry-bridge. Whilst agreeing with the author that the train ferry system was an inestimable boon to the nation during the war, and had been a very great factor in winning the war, he was not so sure that it was going to be as useful in time of peace as a commercial venture. The carrying of merchandise in peace time, and the carrying of war material in war time, were rather different things. The train-ferry system would be very useful if the wagons containing the merchandise could be run direct, say, from Paris to Manchester, without having to unload; but he imagined that it would be necessary to unload the wagons and sort out the goods either at Havre or on this side, and if that had to be done, a great deal of the advantage of the train ferry, which was reaped in the direct transit of munitions of war, would disappear. It might be possible to continue to use the train ferry at Richborough if the coalfields developed and coal was shipped direct to France.

**Mr. H. J. Deane** said that whilst Richborough had been subject to a very great deal of adverse criticism, there was no doubt that it had had very good results indeed from the military point of view. Although it had been enormously costly he thought it could be said that it had served its purpose admirably. It would be a great advantage if the author could give a skeleton plan showing the general lay-out of the port. The paper was singularly devoid of plans. With regard to the wharf wall, there was no indication as to what the rate of progress in the construction was. He believed the wall was 2,200 ft. long, and a considerable amount of time must have been taken up in the work. The paper did not say whether the work was started from one end, or from both ends at the same time, or whether it was started at several points and joined up where each part met. The importance of the work, from the engineering point of view, could best be realized when it was remembered that the bulk of the land on which the port was constructed was water-logged. The dredging operations at Richborough had considerable interest for him, because the Inland Water Department hired three of the Port of Dover dredgers, one of which had a capacity of 430 yards per hour in stiff sand and gravel, the second 300 yards, and the third 765 yards per hour. He was sorry the author was not able to give in detail the costs of the working of the train-ferry system. Although a good many figures were given there were others which were necessary in order to arrive at a true appreciation of the position. The author stated that Great Britain was a country peculiarly suited for the development of a canal system, but he was not sure that he quite agreed with this. There were many areas which could be developed in this way, but as soon as they got into the more hilly districts, then the necessity for constructing locks entered into the matter and was an extremely important factor in the cost, and consequently the commercial possibilities.

## THE LECTURER'S REPLY.

Owing to lack of time the author was only able to touch upon a few points in his reply. The point raised by Mr. Wentworth Sheilds, as to the difficulties of working a train-ferry system for ordinary commercial purposes, he could not quite follow. He saw no difficulty in making up the goods at the sending end in parcels for particular destinations, and there would, therefore, be no necessity to unload the wagons at one of the ports for this purpose. The author was not able to go further into the other matters raised.



# RENEWAL OF SUMMERHILL BRIDGE, DUBLIN, WITH REINFORCED CONCRETE.

*An interesting description of the reconstruction of an old bridge with reinforced concrete is given in the following short article. We call attention to the method of procedure, the old bridge being moved half at a time, the first half being removed in 2½ days, and the new reinforced concrete work, consisting of pre-cast sections, was constructed in 17 hours.—ED.*

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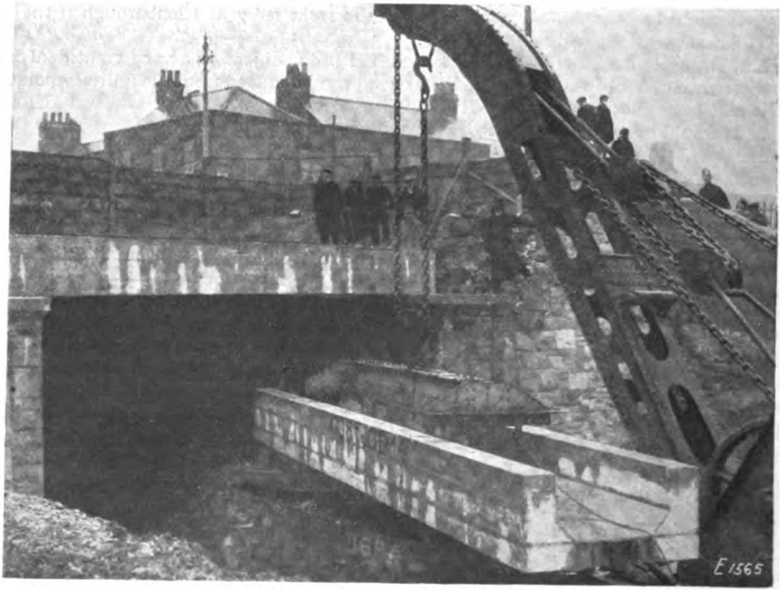
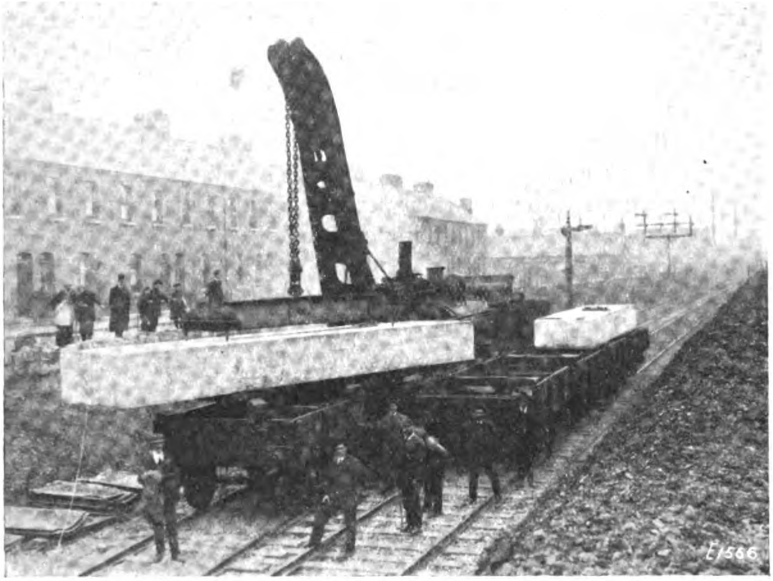
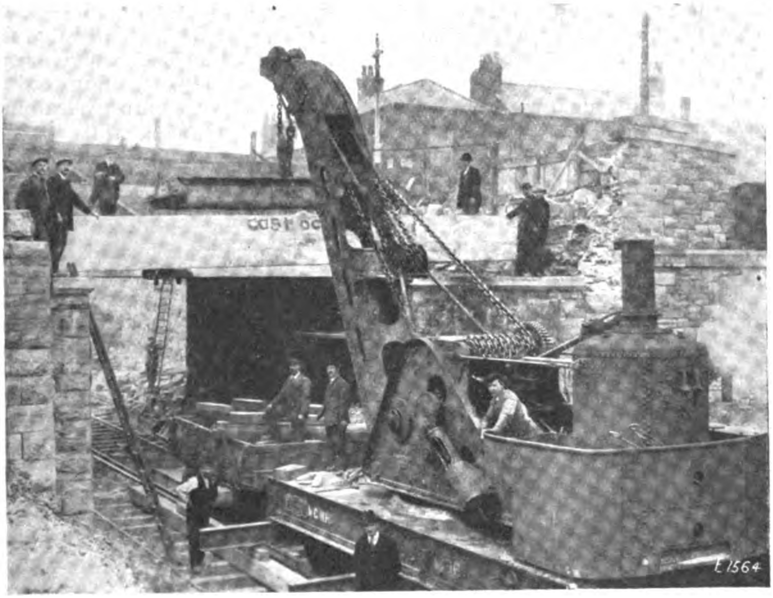
SUMMERHILL BRIDGE runs over the Midland Great Western Railway near Dublin, and the old bridge was composed of thirteen plate girders, over a 27 ft. 8 in. clear span, and spaced at 5 ft. 3 in. centres, with a total width between parapets of 61 ft. 0 in. These girders were built into the abutment walls and lattice braced beneath. The bridge decking was formed of cambered floor plates bolted to the girders, and the bridge carried heavy city traffic and a double line of tramway track over the company's running lines.



CHANNEL BEING HOISTED TO POSITION.



CHANNELS BEING CONVEYED TO POSITION.



CHANNEL BEING PLACED IN POSITION.

The reconstructed bridge is made of 12 channel sections of reinforced concrete, cast at the railway company's concrete works, and erected by them, the reinforcements being designed and supplied by the British Reinforced Concrete Engineering Co., Ltd., under instructions from Mr. A. W. Bretland, chief engineer of the Midland Great Western Railway of Ireland. The sections under the roadway are laid with the flanges of the channels pointing downwards, but those under the footpaths have the flanges pointing upwards, so that the channel forms a trough in which the pipes for gas, water, etc., are laid. The illustrations show channels of each type being carried towards their positions, and the second channel (weighing 19 tons) on the point of being laid in position.

One half of the old bridge was demolished and renewed first, and the traffic diverted to this portion before proceeding with the remainder of the work. The removal of the old steelwork exclusive of roadway and filling in the case of the first half of the bridge occupied 2½ days, or approximately 22 working hours. The *renewal* of the first half of the bridge was carried out in 17 working hours

With regard to the removal of the old steelwork on the second half of the bridge, the work occupied 14 working hours, and the renewal of this portion was completed in 12 working hours. The existing abutment walls in each case had to be lowered 15 in. in order to preserve the former road level and allow for reinforced concrete bedplates being erected. These bedplates were pre-cast, each being approximately 31 ft. 6 in. long by 23 in. by 9 in.; two covering one abutment.

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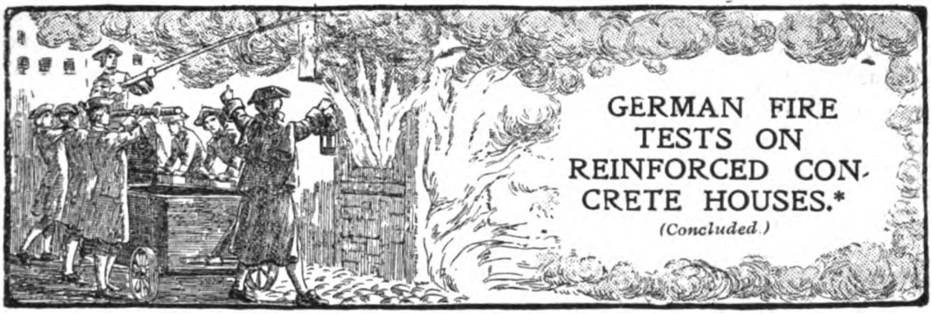
## MEMORANDUM.

**A Reinforced Concrete Bridge at Wellington, N.S.W.**—A new reinforced concrete bridge was officially opened at Wellington on February 3rd. This bridge is 576 ft. long, with a carriage-way of 20 ft., and a footway of 5 ft. The two river-spans are 121 ft. 5 in. centres, and the approach spans consist of 11·30 ft. reinforced concrete beams. The piers throughout are of reinforced concrete, with timber pile foundations, the height of the centre pier from top to bottom of concrete being 70 ft.

The work was designed in the Public Works Department under Mr. R. E. Jones, M.Inst.C.E. The steel superstructure was supplied under contract by the Walsh Island workshops, whilst the reinforced concrete spans and the erection of the steel superstructure for the 120 ft. truss spans, together with reinforced concrete deck, were carried out under contract with the State Monier Pipe Works, all being under the direction of Mr. Percy Allan, M.Inst.C.E., M.Am.Soc.C.E., chief engineer for national and local government works, with Mr. F. J. Morrice as the supervising engineer in charge of the works. The roadway on the approach spans is covered with tarred metal, while that on the steel spans has a concrete wearing surface on the reinforced concrete deck slab.—*Commonwealth Engineer.*



# GERMAN FIRE TESTS ON REINFORCED CONCRETE HOUSES.*

*(Concluded.)*

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*The illustrations in this article are reproduced from the report on the tests mentioned in the footnote on this page. In the May number the preliminary preparations for the tests were described.—ED.*

**Note on House IV.**—The most remarkable feature of the test was the explosive nature of the destruction. With violent detonations the concrete suddenly broke into small pieces, some of which were hurled a distance of 40 metres. The damage due to the upper fire is illustrated by *Figs.* 2 and 3. (See previous issue).

The marked discrepancy in resistance between the two houses called for further investigation. Very little damage was done to House III., and it seemed possible that the greater dampness of the upper walls of No. IV. had contributed to the difference of behaviour, for it had rained heavily just before the upper test of House IV. It was therefore decided to repeat the tests on House III., and this was done a year later at a time when the walls had been thoroughly soaked by a rain of several days' duration. The results were practically identical with those obtained during the first tests. The same fractures opened up as had previously formed, and they closed a second time when the building cooled. As shown by the temperature readings, the distribution of heat and the thermal effects as a whole were also very similar. No detonations occurred and the entire house had almost the same aspect as before. It became clear, therefore, that the damage done to House IV. could not be assigned only to the dampness of the upper walls, and that it must have been mainly due to the use of granite instead of basalt in the parts affected. It should be noticed, however, that House III. was a year older in the second trial, and it may have been more impervious and internally drier as a result of the first fire and subsequent hardening by expansion of the cement. It is possible, too, that during the first tests the basalt-concrete may have been less porous than the granite concrete. Unfortunately, data as to specific gravity, voids, ratio of absorption, etc., are not given, but it is promised that in a later investigation an attempt will be made to clear up the difficulty. The German report does not point out the ascertained fact that at high temperatures granite expands to a far greater extent than basalt, and here is at least a contributory cause for the forcible separation of the granite concrete from its reinforcement. The thermal stresses set up between granite and steel must have been much more powerful than those between basalt-concrete and steel, and that such a difference is a factor of prime importance has been demonstrated in carefully controlled British fire tests as well as in actual conflagrations.

**Penetration of Heat.**—The distribution and variation of temperature in the basalt-concrete and granite-concrete walls were found from measurements made at different depths from their inner surfaces and at different times during the tests. The results are fully discussed, but it will be sufficient here to give the average results obtained after 60 and 100 minutes in each case, in order to make a simple comparison between the temperatures to which the two materials were subjected.

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* Brandproben an Eisenbetonbauton, 1914-15. II. Bericht, Erstattet von Prof. M. Gary. Deutscher Ausschuss für Eisenbeton, Heft 33, pp. 66. Berlin, 1916.

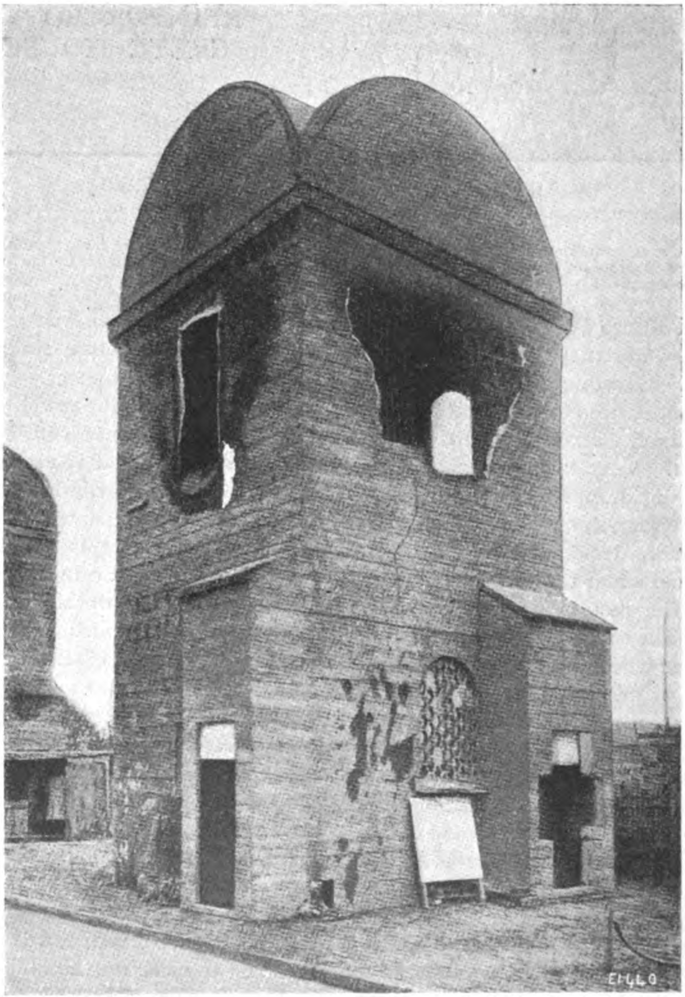

Fig. 5. Appearance of House IV. during the Lower Fire.

It is clear from the maximum temperatures attained, and the heat penetration, that despite its bad behaviour the granite concrete was not heated to the same extent as the basalt-concrete. The figures show, moreover, that the latter did not conduct heat as well as the granite concrete up to 3 or 4 cm., though at 5 cm. the conductivities were practically equal.

**Crushing Strength.**—The crushing strengths of the various kinds of concrete were determined before and after the fire tests in order to ascertain the average loss of strength. As already stated, some of these measurements were made on cubes

SUMMARY OF HEAT-PENETRATION DURING LOWER FIRE TESTS.

| Depth from Inner Surfaces of Walls. | Temperatures after 60 minutes. | | Temperatures after 100 minutes. | |
|---|---|---|---|---|
| | Found. | Average. | Found. | Average. |
| Basalt: | | | | |
| 1 cm... .. | 365<br>375<br>248<br>262 | 312° C | 395<br>420<br>360<br>336 | 377° C |
| 3 cm... .. | 200<br>315<br>161<br>140 | 204° C | 245<br>370<br>262<br>250 | 282° C |
| 5 cm... .. | 175<br>285<br>100<br>100 | 165° C | 200<br>340<br>154<br>162 | 214° C |
| Granite: | | | | |
| 1 cm... .. | 315<br>325<br>110<br>256 | 252° C | 340<br>357<br>220<br>345 | 316° C |
| 3 cm... .. | 245<br>190<br>98<br>110 | 181° C | 285<br>262<br>195<br>290 | 258° C |
| 5 cm... .. | 175<br>110<br>81<br>120 | 122° C | 190<br>170<br>145<br>211 | 179° C |

prepared from pieces cut out of the walls before and after the fires. Others were made on 20 cm. cubes prepared in iron moulds from the mixtures used in the construction of the two houses. Some of the cubes were placed in the houses with alloys to indicate the temperatures reached during the tests. The average figures obtained are summarised below, those in parentheses being unreliable on account of discrepancies between the individual results from which they are calculated.

The above results are not all strictly comparable, since the temperatures to which the cubes were exposed varied from +93° C. (granite, gravel, and pumice) to 230° C. (slag), and 412° C. (basalt). As recorded, however, the figures give the percentage loss of strength on an average as 47 per cent. for pumice, 40 per cent. for slag, 23 per cent. for gravel, 17 per cent. for granite, and for basalt, curiously enough, an increase.

**Behaviour of the Houses during Demolition.**—As it was found desirable to repeat the tests on House III., House IV. was demolished while the former was awaiting its second trial. It was decided that the whole building should fall entirely over, CRUSHING STRENGTHS OF CONCRETE BEFORE AND AFTER THE FIRE TESTS.

| Aggregates of Concretes Tested. | Crushing strength in kilos per sq. cm. | | |
|---|---|---|---|
| | Not Fired. | | Fired. |
| | 70 days old | 16 months old. | 16 months old. |
| Basalt : from wall, 1 : 4 : 4 | 138 | (119) | 112 |
| Basalt : cubes, 1 : 4 : 4 | 137 | (186) | 204 |
| Basalt : cubes, 1 : 4 | 182 | 207 | 266 |
| Granite : from wall, 1 : 4 : 4 | 308 | 282 | 225 |
| Granite : cubes, 1 : 4 : 4 | 213 | 237 | 234 |
| Granite : cubes, 1 : 4 | 206 | 238 | 173 |
| Gravel : from wall, 1 : 4 | 295 | 326 | 249 |
| Gravel : cubes, 1 : 4 | 276 | 288 | 221 |
| Pumice : cubes, 1 : 5 | 57 | 57 | 30 |
| Blast furnace slag : cubes, 1 : 5 | 185 | 206 | 123 |

so that the crushing might be complete, and the débris more easily dealt with on the ground. The concrete on each wall except the western was cut away to a height of 50 cm. above the ground and wooden props inserted for support. These were surrounded with shavings and the whole soaked with petroleum and fired. After a quarter of an hour the house suddenly bent over towards the east, the east wall being largely destroyed, while the north and south walls remained standing, and prevented the house from toppling over. The staircase pillars were then cut through and removed, and the house was finally pulled slowly over with strong wire ropes. Large pieces remained intact, and most of the plain concrete walls were undamaged by the fall. See *Fig.* 6.

House III. was demolished by firing without a check, and despite a severe crash the thin upper walls and gables largely retained their coherence. See *Fig.* 7.

**Concluding Remarks.**—The Committee considers the power of resistance shown by the two test-houses to be surprisingly satisfactory in view of the strong fires and unfavourable circumstances to which they were exposed. As regards House III., the fire-resistance was certainly of a high order, and demonstrates unequivocably the superiority of basalt over granite as an aggregate.

The behaviour of the stairs was also very instructive, as both the reinforced concrete and artificial stone steps continued to stand up well, while the sandstone steps failed badly. The security of staircases against fire should be considered one of the principal demands put upon a building. Through the failure of a staircase the inhabitants of entire storeys may be endangered. A fire breaking out in the well of a building is often the most dangerous, such fires having caused many deplorable accidents. The recent Cross House fire in Newcastle was a tragic example, though in that building it was not the failure of the stairs which brought disaster but the lack of any alternative means of exit save by the windows. The fire tests described in this article vindicate the justice of a Prussian decree of 1911, which reads : " The principal staircases in buildings of over twenty beds shall be made fire resisting; i.e., made of concrete or artificial stone with steel reinforcement, exclusive of natural stone, and shall be surrounded throughout by massive walls."

The chief problem arising out of the tests concerns the puzzling occurrence of explosions in the reinforced granite-concrete. In practice this behaviour might seriously hinder work of rescue, for it introduces an additional risk of injury to the hazardous duties of firemen. It is to be hoped that the cause of the phenomenon will be firmly established, and that suitable measures may be taken to prevent its occurrence. Experience consistently supports the conclusion that, from the point of view of fire resistance, granite, especially when it is coarse in grain, is an aggregate to be avoided.

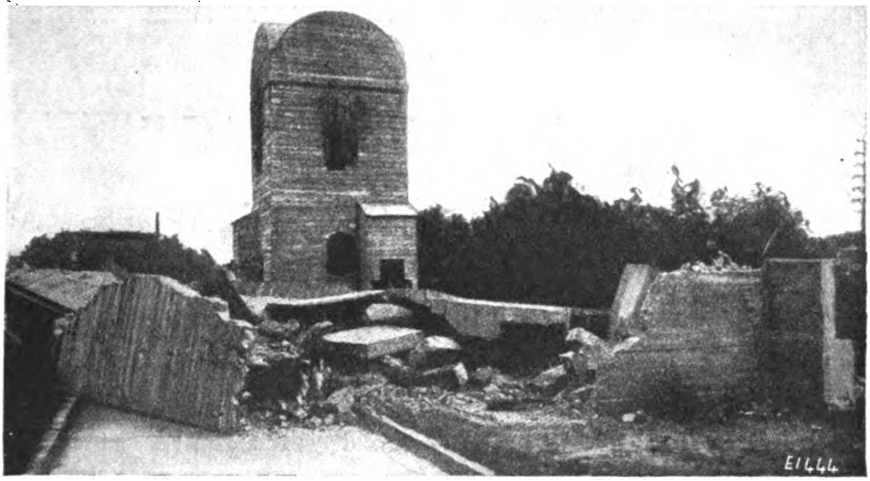

FIG. 6. DEBRIS OF HOUSE IV. AFTER FALLING. HOUSE III. IS SEEN BEHIND.

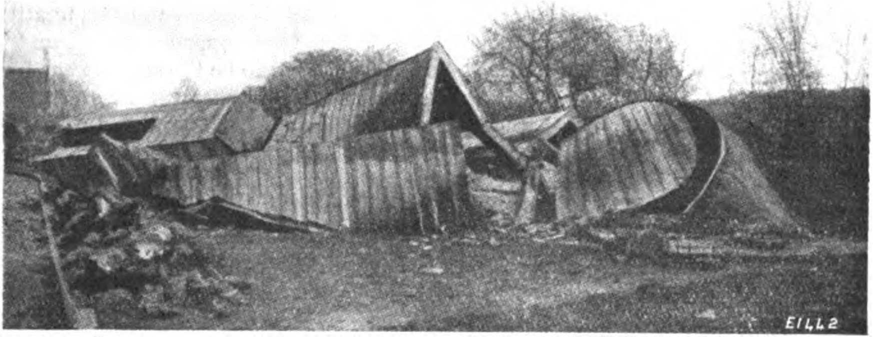

FIG. 7. DEBRIS OF HOUSE III. AFTER FALLING: VIEWED FROM THE NORTH-WEST.

# "CONCRETE SHIPBUILDING"

## REINFORCED CONCRETE SHIPS, BARGES, AND PONTOONS.

### By ALFRED B. SEARLE.

### CHAPTER XII. (*concluded*).

### RELATIVE COSTS OF CONCRETE VESSELS.

THE following figures, compiled by T. G. Owens Thurston, represent a reasonable analysis of the manner in which the total cost of a 375 ft. steamer would be made up if built in steel :—

Bare hull, 53 per cent. ; machinery, 26 ; remainder, 21, total, 100. If the dead weight carried is regarded as a measure of the earning capacity, a reduction of 17 per cent. in this respect must be balanced by a corresponding reduction in the prime cost of the ship. The reduction in this instance will be 17 per cent., multiplied by 100/53, or 32 per cent. in bare hull cost, since the cost of the other two items remains unaltered. A closer investigation will show that this is only a very rough approximation, and that the absolute cost of running the vessels (even if it be taken to be the same in each case) the percentage of profit assumed, and other matters of accountancy have a powerful influence on the result. These, however, all have the effect of increasing the figure of 32 per cent., noted above, and it can be stated with fair certainty that reinforced concrete will not replace steel for ordinary cargo carriers unless the hull can be built for considerably less than half the cost of building the same hull in steel. Where the additional weight is more than counter-balanced by the durability and reduced prime cost of the new material there is reason to expect that its adoption will naturally follow. This is a very hopeful feature with regard to concrete, as will be seen from the following chapter.

About a year ago the demand for tonnage was so great that the relative costs of ships of concrete and steel or concrete and wood were not as important a consideration as now and in the near future, when conditions again approach the normal.

The lower first cost of concrete vessels is partly due to the fact that no heavy plant is required for reinforced concrete work, partly due to the relatively lower cost of the reinforcement as compared with other forms of steel and partly to the lower rates of wages paid to the men employed. The saving in the cost of steel seldom exceeds 50 per cent. The rate of wages appears likely to increase rather than diminish as a class of skilled concrete and reinforcement placers has begun to arise.

Any comparison of the relative cost of concrete and other vessels must take into account so many considerations that, at present, no satisfactory degree of accuracy can be obtained. The figures stated above show, however, that on an average the cost of a concrete hull is about 70 per cent. of that of a steel hull of the same dead-weight capacity.

In the case of *pontoons*, the cost of construction (prior to 1914) was found to be about half, and the cost of maintenance and repairs only one-quarter to one-third that of similar structures in steel.

The construction of concrete vessels is as yet an infant industry, though in some respects a promising one. Hitherto, builders have largely followed the design of those who are accustomed to work with wood or steel, and only to a small extent has the inventive ability of specialists in concrete construction been allowed free play. In course of time, the latter will become more familiar with the principles underlying the design of ships, apart from the materials of which they are constructed, and they will then be able to develop on lines at present unthought of, or possibly regarded as merely visionary. The unprecedented demand during the war having now largely abated, the semi-Government yards where concrete ships were being built have been closed down, and private enterprise, realising some of the disadvantages inherent to those shipyards, has not continued the construction of concrete vessels. Such an action must not be understood to mean that concrete vessels are a failure ; on the contrary, within certain limitations they are undoubtedly a success.

Much more could be argued in favour of the use of reinforced concrete in shipbuilding, but it is not the purport of the author to enter into further technicalities ; he has written solely with the intention of bringing out, as simply as possible, the proved advantage and superiority of the concrete vessels under certain conditions. In summing up, therefore, it is quite evident that in the various types of reinforced concrete vessels is to be found a method of constructing ships which, compared with the others, provides—at a lower cost to the owner—an equally strong and more scientifically constructed vessel, which carried a corresponding dead weight, reduces the cost of maintenance and presents a greater resistance to damage, besides possessing other advantages. A shipbuilding material and a system capable of giving effect to so many important improvements certainly merits the serious consideration of owners of all types of craft.

It now remains for energetic and far-sighted commercial men to gather round them engineers and other technical men, each of whom has a special knowledge of one branch of the many subjects which are involved. By correlating the knowledge and experience of men in these various fields of work, and applying it definitely and boldly to the construction of concrete vessels of many kinds, this country will be able to make still further use of its many material advantages as a shipbuilding centre. Such men may also do invaluable work by sending out small parties of skilled workmen to supervise the erection of concrete vessels by natives in far-away parts of the Empire, as the use of concrete for this purpose offers facilities for opening up such countries as Central Africa, and inland waterways of India, Canada, Australia, and even China to an extent which it is quite impossible to judge at present.

Hitherto, the construction of boats has been limited to localities where wood, steel and skilled labour are available. By the use of reinforced concrete vessels can be built which do not require these conditions, and by this means a vast extension of shipbuilding and Empire building becomes possible.

# THE FOREIGN PRESS.

*The following are abstracts taken from the foreign Press relating to concrete construction.—ED.*

**Light Concrete Hangars with Curved Roofs.**—The following is taken from an article in *Le Constructeur du Ciment Armé*. The writer states that reinforced concrete has the following advantages for hangars : (*a*) They are fire-resisting ; (*b*) the cost of repairs is reduced to a minimum ; (*c*) they are extremely rigid, due to their monolithic structure.

On the other hand, the author maintains that there are certain disadvantages, due mainly on account of the necessity of shuttering. These disadvantages he states to be as follows: (*a*) They necessitate the use of shuttering during construction; (*b*) they cannot be dismantled or altered.

In the case of light hangars these difficulties are increased by : (*a*) the shuttering is costly and complicated; (*b*) the cost of the shuttering is the same as for a hangar of heavier construction ; (*c*) the construction is generally more massive than would be necessary if wood or galvanised iron is used.

Hangars with curved roofs have the following advantages : (*a*) The amount of material used is reduced to a minimum ; (*b*) it is possible to obtain a sufficiently satisfactory impermeability with a simple coating of rich cement ; (*c*) the shuttering is simplified by placing the ties above the roof ; (*d*) the curved pieces of shuttering may be used repeatedly ; (*e*) the dismantling of the curved portions of the roof may be effected much more rapidly (in about a fortnight) without danger.

The following precautions are essential : (*a*) The height to the eaves must not exceed 16 ft. ; (*b*) the longitude distance between the pillars must not exceed 16 ft., and the span must not exceed 40 ft., thus giving a maximum free space of 15 × 40= 640 sq.ft.

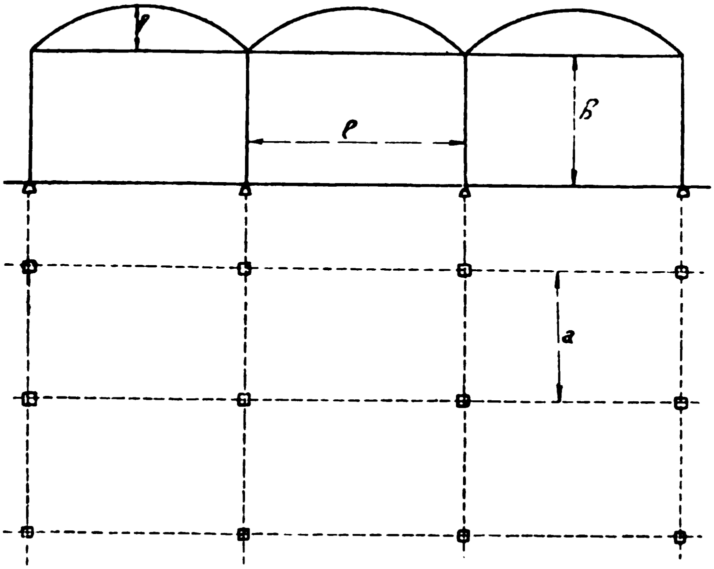

FIG. 1—DIAGRAM OF ELEVATION AND PLAN.

The following suggestions apply to a simple hangar, open on all four sides. The loads carried by the hangar include :—

(i.) Its own weight, calculated on a density of 2,400 kg., corresponds to a load of 300 kg. per sq. in., or 7,333 lb. per sq. ft.

(ii.) A fall of snow equivalent to 1,464 lb. per sq. ft. of covered surface or a surcharge of 732 lb. per sq. ft. of snow added to the effect of a wind with a pressure of 3,660 lb. per sq. ft. of normal surface.

(iii.) In calculating the sizes of the pillars it has been assumed that all the four walls were in position and had to resist a wind-pressure of 3,660 lb. per sq. ft. at the top, decreasing gradually to nil at the base of the wall.

(iv.) The concrete contains 560 lb. of Portland cement per cubic yard and has a safe compressive strength of 714 lb. per sq. in.

The essential details of the structure are shown in Figs. 1, 2 and 3, and include :

(*a*) A rib 25/18* shown in the roof gutter for carrying off water.

(*b*) A tie composed of one piece of 16/18, and supported by hanging truss-posts o 6/18. These must be protected from damp and acid vapours by a good coat of paint These ribs, which have a span of 10 m., are 4 m. apart. They rest on pillars 18 × 23 cn.

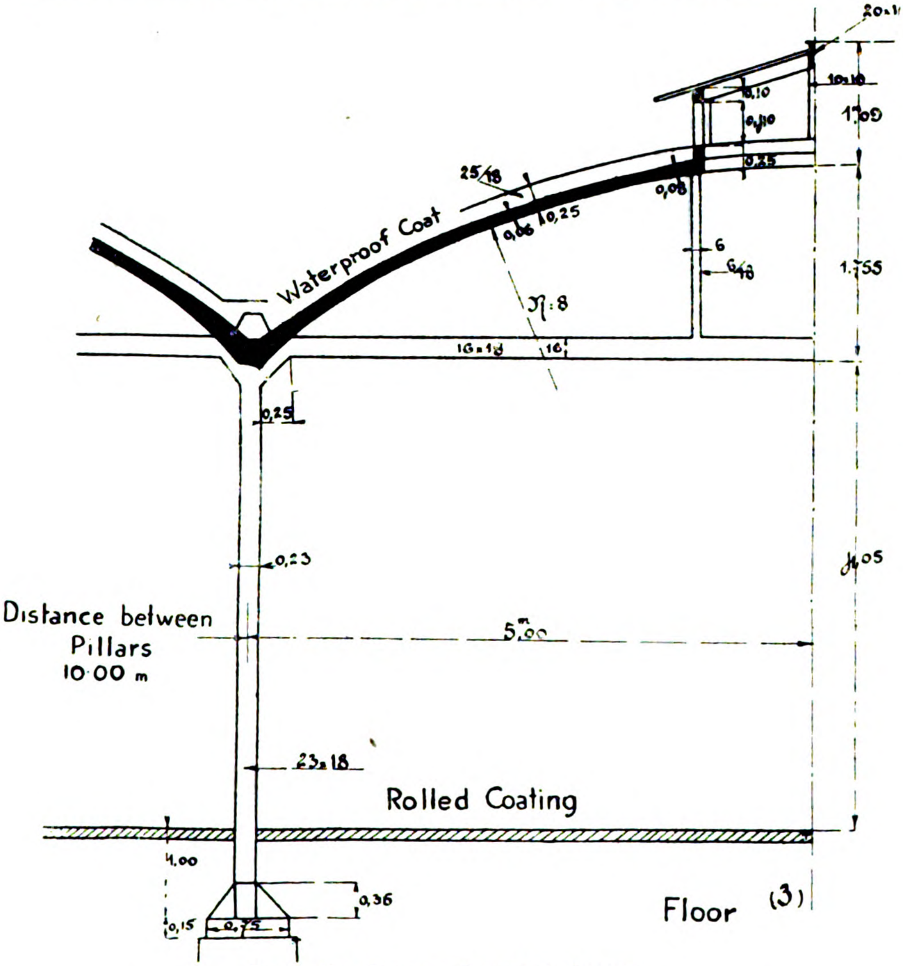

FIG. 2.—HALF VERTICAL TRANSVERSE SECTION.

Those resting by means of a slab 0·75 × 0·75 m. on a thin slab of concrete 0·90 × 0·90 m., are sufficient even for a poor soil.

Side and end walls are easily built of bricks crossed with wooden ties, or reinforced concrete constructed *in situ* without shuttering.

If the foundation is really bad, an ashlar course of reinforced concrete may be built under the partitions and between the feet of the pillars.

The portion of the roof between the rafters is composed of a slab of reinforced concrete about 2½ in. thick. The ties project from this in such a manner as to form a continuous intrados, and thus simplify the shuttering. Resistance to weather is assured by the provision of a cement cover of 990—1,100 lb., extending to the face of the extrados. Outside openings in the end and side walls and a lantern 7–10 ft. wide at the top of each roof, suitably glazed, provide light and ventilation.

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*All the measurements shown in the illustrations are in the metric system. 1 metre = 39·37 in. 1 cm. = 4 in.

The ties cross at the base of the lantern. As they are 13–16 ft. apart one or two keys each 6 in. square should be fixed between each rafter to connect the bases of the lantern. This arrangement gives sufficient light when only three spans are used at a time—*i.e.*, when the whole structure is not more than 100–120 ft. wide.

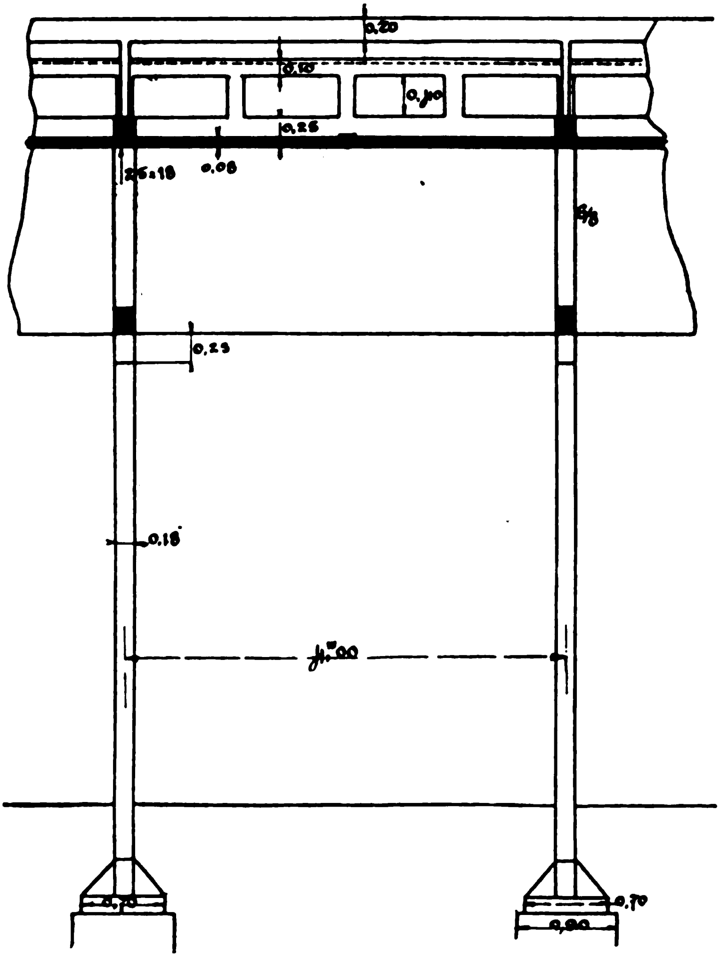


FIG. 3.—PART LONGITUDINAL SECTION.

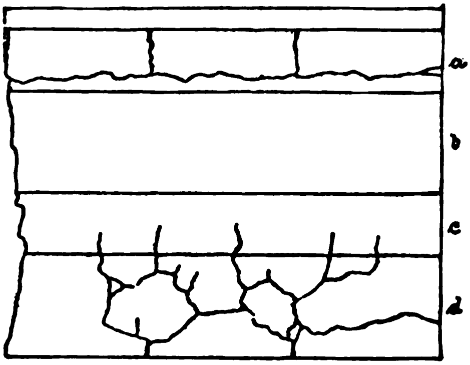
Expansion joints should be provided every 120–140 ft., allowing a space of ¾ in. in the axis of one of the rafters, this being made of two pieces each 10 in. by 5 in. The slit is extended to 5 ft. underneath the wall-plate. The position of the slit relative to the top of a rafter adds greatly to the efficiency of the means commonly used to masque it.

The only part of the shuttering which has any special interest is that relating to the intrados of the roof. It is advisable to have ties arranged to prevent the wall-plate projecting between the pillars. It is then possible to use the same curve-pieces (made originally for the chief span of 40 ft.) for the lower spans. It is sufficient to preserve the same outline of neutral fibre in the tie of the various ribs to pass out of the lantern and cross on 20, 40 or 60 in the ends of the curve-pieces of the two adjacent chambers. The bottom of the wall-plate is then closed by a simple plank.

The arrangement shown effects a great saving in materials, especially when a large number of structures are to be built in the same locality, but it is not applicable to those with spans of more than 40 ft., or with distances of more than 16 ft., without serious risk of accident. Where these dimensions are not exceeded, this method of construction is cheap, rapid, light and fire-resisting.—*Le Constructeur du Ciment Armé.*

**Cracks in Concrete.**—A concrete block measuring 20 in. by 13 in. by 3 in., the top and one side of which was covered with a granitic concrete, whilst the remainder of the block was composed of sand-concrete, developed cracks as shown in the accompanying illustrations, in which *Fig.* 2 shows each of the sides of the block arranged on a single plane. The position of the sides may be seen in *Fig.* 1. It will be seen that one of the cracks runs the whole length of the top and part of the way along side *d* and spreads out in a curious manner on the latter. Side *b*, on the contrary, was quite free from cracks. The whole block was slightly distorted, the side *b* being bowed inwards and *d* slightly outwards.

Fig.2



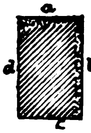
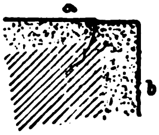


Fig.1

Fig.3



It was concluded that the cracks are of two kinds—those due to the difference in the shrinkage of the two kinds of concrete employed in the block and specially shown in side *a*, and those of an indirect character shown in side *d*. The fact that no cracks occurred in side *b* is highly instructive, for it shows that the expansion of the cement used could not have caused the cracks. Moreover, the hollowing of side *b* and the bulging of side *d*, taken in conjunction with the moments of resistance of these two sides and of the top and bottom of the block, show quite clearly that it was the distortion of the two sides which caused the cracks in *d* and kept *b* whole! It is well known that cracks are far less likely to form in a hollowed than in a bulged portion as in the former the thrust is against the top of an arch (*i.e.*, the hollow), whilst in the latter it is against the concave portion (*i.e.*, the bulge).

The long crack in side *a* is clearly shown in *Fig.* 3 to be due to shear, and was probably caused by the shrinkage of the coating of granitic concrete on side *b* as well as on *a* shrinking more than the remainder of the block. At the point where the crack occurs, the shrinkage stress is at a maximum, for the material forming the top *a* may be regarded as shrinking away to the left from the point of fracture, whilst the concrete on side *b* is shrinking in a downward direction. Under such circumstances, unless the main mass and the coating have exactly the same shrinkage there is almost certain to be a crack.

Had the side *d* been covered with the granitic concrete it seems almost certain that the side *b* would also have been cracked.

The lesson to be learned from this example, is that great care must be taken in coating concrete blocks with a facing or grouting material so that the two concretes shall have precisely the same shrinkage. Such precautions have long been known in the manufacture of bricks, etc., but they are liable to be overlooked in making concrete blocks, though they are just as essential as in other industries.—*Tonind. Ztg.*

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER III.—*continued.*

### *Beams and Slabs.*

40. In the preceding sections it was shown how to calculate the moment of resistance of a slab of any thickness.

As an example, take a 6 in. slab. The centre of the steel rods will need to be ¾ in. from the bottom (to allow ½ in. cover or protection of concrete.

Hence $d = 6$ in. $-$ ¾ in. $=$ 5¼ in.

We generally calculate the moment of resistance for a strip of slab 1 ft. wide so that the breadth is

$$b = 12 \text{ in.}$$

Then from our formula the moment of resistance is

$$R = 95bd^2$$
$$= 95 \times 12 \text{ in.} \times 5\tfrac{1}{4} \text{ in.} \times 5\tfrac{1}{4} \text{ in.}$$
$$= 31{,}500 \text{ in lb.}$$

It was shown in section 38 that this formula was based on a percentage of steel of ·675, so that the area of steel rods required per foot width would be

$$A = \frac{\cdot 675}{100} \times 5\tfrac{1}{4} \text{ in.} \times 12 \text{ in.}$$
$$= \cdot 425 \text{ in.}^2.$$

The area of a ½ in. round rod is ·2 sq. in., so that ½ in. rods at 6 in. centres give ·4 sq. in., which is near enough for most practical purposes.

41. We now need to consider how this calculation helps us to tell what safe load the slab will carry on different spans and under different conditions.

This is done by calculating the *bending moment* in the slab under these loads and conditions, and provided this bending moment does not exceed the resistance moment just calculated, the slab is safe under these loads and conditions.

A bending moment, like a resistance moment, is a force multiplied by a distance.

42. The simplest case is a cantilever carrying a point load $W$ at the unsupported end, see *Fig.* 6 (*a*).

Here the bending moment is the product of the load $W$ by the length of the cantilever $l$, or

$$M = Wl$$

When the load is uniformly spread over the cantilever it acts at a point half way along, so that the moment is

$$M = W \times \frac{l}{2}$$
$$= \frac{Wl}{2} \quad \text{(See } Fig. \text{ 6}b\text{).}$$

In a beam resting on two supports carrying a concentrated load at the centre, the bending moment is a maximum at the centre.

It will be noticed that if the beam and its loads are inverted, the case is exactly similar to two cantilevers (as in *Fig.* 6*a*) put back to back, the load on the cantilever being $\frac{W}{2}$ (since clearly half the load is carried on each support), and the length of the cantilever being $\frac{l}{2}$, or half the length of the beam.

So that $M = \frac{W}{2} \times \frac{l}{2}$ (See *Fig.* 6*c*).

$$= \frac{Wl}{4}.$$

In a beam resting on two supports the moment is greatest at midspan and is calculated as follows :—

Considering the loads to the left of the centre section, we have two, the end reaction acting upwards at a distance $\frac{l}{2}$ and half the distributed load acting down at a distance of $\frac{l}{4}$.

The moment is therefore the difference between these two moments, so that

$$M = \frac{W}{2}\times\frac{l}{2} - \frac{W}{2}\times\frac{l}{4}$$

$$= \frac{Wl}{8}$$ (See *Fig. 6d*).

In the above cases the slabs have merely been supported at their ends.

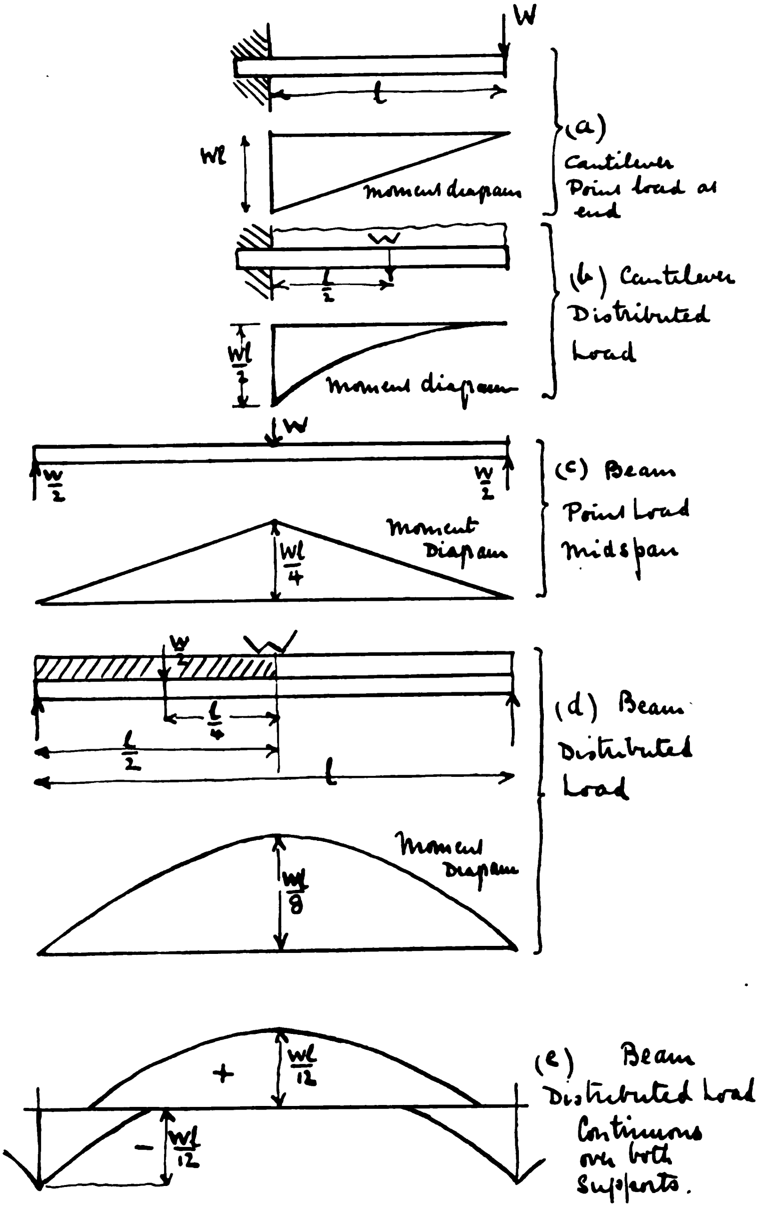

W
l
Wl
Moment diagram
(a) Cantilever Point load at end
W
l/2
Wl/2
Moment diagram
(b) Cantilever Distributed Load
W
W/2
W/2
Moment Diagram
Wl/4
(c) Beam Point Load Midspan
W/2
W
l/4
l/2
l
Moment Diagram
Wl/8
(d) Beam Distributed Load
+
Wl/12
-
Wl/12
(e) Beam Distributed Load Continuous over both Supports.

FIG. 6. BENDING MOMENT DIAGRAMS.

When they are continuous over several supports, as in *Fig.* 4, the moments are less than $\frac{Wl}{8}$.

This case is one of some complexity and is fully dealt with in the author's *Reinforced Concrete Design*, Vol. II., shortly to be issued by Messrs. Arnold, but as a rough approximation may be taken as $\frac{Wl}{12}$ at midspan and at the support.

43. Let us now, as an example, consider a 6 in. slab, carrying 100 lb. per sq. ft. (live load) on a 12 ft. span, continuous over several supports.

The load per sq. ft. will be live 100 lb.
dead 75 lb.
total 175 lb.

The total load on a strip 12 ft. long 1 ft. wide will be

$$W = 12 \times 175 = 2{,}100 \text{ lb.}$$

The span $l = 12$ ft. $= 144$ in.

NOTE.—We keep lengths in *inches* when calculating moments, so as to work in the same units as with our moment of resistance.

Hence we have the bending moment

$$M = \frac{Wl}{12} = \frac{2100 \times 144}{12}$$
$$= 25{,}200 \text{ inch lb.}$$

It will be seen this is rather less than the moment of resistance of a 6 in. slab given in paragraph 40, so that the slab would be quite safe.

This is an example of the rule in paragraph 36 of a continuous slab having its *thickness in inches half its span in feet.*

44. Beams are dealt with in exactly the same way as slabs, and an example will suffice.

Span, 15 ft.
Distributed load, 10,000 lb.
Beam non-continuous.

If the beam is about 18 in. × 12 in. it will weigh 225 lb. per ft., or 3,375 lb., so the *total load* is 13,375 lb.

The bending moment

$$M = \frac{Wl}{8} = \frac{13{,}375 \text{ lb.} \times 180 \text{ in.}}{8}$$
$$= 300{,}000 \text{ inch lb.}$$

The moment of resistance of a beam 18 in. × 12 in. (16 in. depth to steel) is

$$R = 95bd^2.$$
$$= 95 \times 12 \times 16 \times 16.$$
$$= 292{,}000 \text{ inch lb.}$$

which agrees sufficiently well.

The area of steel required would be

$$A = \frac{\cdot 675}{100} \times 16 \times 12 = 1{\cdot}3 \text{ sq. in.}$$

Three ¾ in. rods have an area

$$A = 3 \times \cdot 44 = 1{\cdot}32 \text{ sq. in.}$$

which would do well.

These would be arranged in the beam as at *Fig.* 4 (*a*).

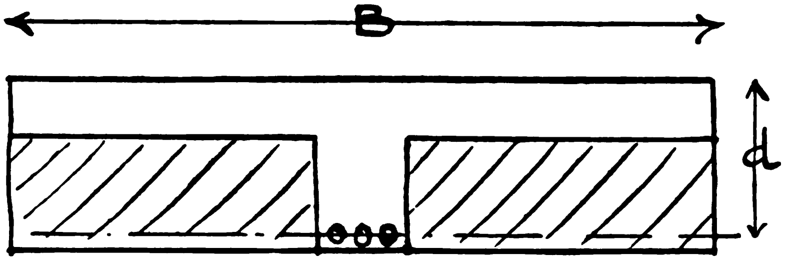


FIG 7. T-BEAMS.

45. Now rectangular beams, designed as in the last example, are the exception in reinforced concrete, since, as a rule, a beam is built to carry a concrete slab, which then adds very much to its strength.

The construction then consists of a slab stiffened by concrete ribs on the underside, and these ribs are then called *Tee Beams*, because part of the slab acts with the beam and gives it the shape of a large T.

Referring now to *Fig.* 7, showing a very wide rectangular beam, it will be remembered that the concrete below the neutral axis (roughly one-third the depth down) is in tension, and this is neglected in the design, so that the two areas shaded can be eliminated without in any way reducing the strength of the beam.

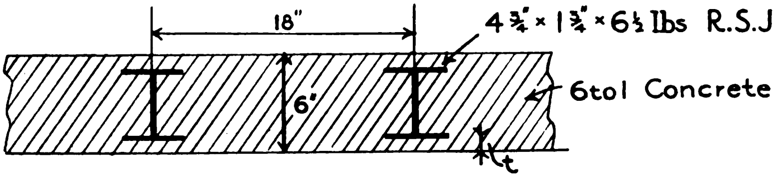
In other words, the strength of the rib and the slab for a width *B* acting together is equal to that of a rectangular beam of width *B* and the same depth as before, providing the steel which would be used in the large rectangular beam is now concentrated in the rib.

This construction is obviously very economical and is largely the cause of the economy of reinforced concrete construction.

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

*In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.—ED.*

*Question.—Please give the general formulæ for finding the moment of inertia, and designing concrete floor with rolled steel joists bedded in concrete as reinforcement as in sketch; also general observations in design, particularly as to safe limits for spacing the beams and the spans, the beams supported by main floor beams; also the minimum thickness of concrete covering "t." Please give safe distributed load for floor as sketch; the span,* 10 *ft.* 0 *in. between main floor beams.*



*Answer.*—The reply to a similar question appeared in our June number, from which the strength of the floor may readily be calculated.

The thickness *t* adds nothing to the strength and is required for protection against corrosion and fire only.

If *t* is made less than half the width of the joists it will be difficult to run the concrete in and secure sound work, but if wire netting is wrapped round the lower flange the protection may be obtained by cement plaster after striking.

The distance apart of the joists should not exceed six times the thickness of the concrete.

When the cover of concrete *over* the joists does not exceed one-sixth of the depth of the joists, the concrete does not add appreciably to the strength of the joists.

## MEMORANDUM.

**Good Concrete Watertight under 35 ft. Head.**—Tests of concrete tanks for watertightness have recently been made by the United States Bureau of Standards. These tanks were of ordinary 1 : 2 : 4 concrete, with only the usual precautions for good material and mixing and placing. For a while the loss increased slightly with time, but after 150 days it was found that the day loss curve took the form of a straight line, showing daily loss had become constant. This loss, however, was so low that the outside of the tanks were dust dry. It is the conclusion, therefore, of the Bureau that 1 : 2 : 4 concrete in this case was sufficiently waterproof for this head.

# CORRESPONDENCE.

*Under this heading we invite correspondence.*

### Concrete Construction in Gold Coast Colony.

*To the Editor of* CONCRETE AND CONSTRUCTIONAL ENGINEERING.

SIR,—In your issue for May there appeared an article on the above subject, including a reference to the water-works at Accra, which is somewhat misleading and unjust to the late Mr. Walter Hunter, to Mr. Bertram Blount, F.I.C., and to my colleague, Monsieur Henri Chabal, E.C.P., of Paris, and myself.

It is stated that the system of multiple filtration adopted at Accra did not afford a water of the standard desired, and that there were objections to the iron process which it had *at one time* been intended to adopt.

In the year 1909 Mr. Bertram Blount investigated the character of the water available for the Accra supply, and recommended the adoption of the iron process, which, of course, necessitates subsequent filtration.

His report was adopted by the Crown Agents for the Colonies and the late Mr. Walter Hunter entrusted the design of the installation to M. Chabal and myself.

I had been for many years connected with the Antwerp water-works, where the iron process was first adopted, in the form of filtration through spongy iron, afterwards modified by forming the ferrous oxide in a "revolver" designed by the late Sir William Anderson, while later still the iron was added in the form of ferric oxide in an apparatus known as the rusting tank, designed by Dr. Kemna.

The installation erected at Accra was designed to be used as a multiple filtration plant either with sand and gravel or with iron in a convenient form in one of the sections, and I had frequent consultations with Mr. Hunter before and during its construction. Mr. Hunter decided to test the installation first with sand and gravel and to add the iron later if it should be required.

The figures given by the consulting chemist after his preliminary investigations indicated that the maximum impurity of the Densu River water would be represented by a content in albumenoid ammonia of ·05 parts per 100,000, and we were asked to design a plant which would reduce the albumenoid ammonia to ·008 parts per 100,000, a difference of ·042 parts per 100,000.

In frequent tests with the installation after completion this difference was achieved, but it was found that the maximum impurity (due to decaying vegetable matter) in the raw water of the Densu was very much greater than had been supposed and frequently reached a figure 150 per cent. higher than the original estimate of Mr. Blount.

Under these circumstances I stated at once that the installation as designed would not effect a reduction to ·008 parts per 100,000 of albumenoid ammonia without the use of ferric oxide, and as, unfortunately, Mr Hunter had died in 1914, I requested the Crown Agents to allow me to confer with Mr. Blount with a view to the necessary modification of the filtering materials.

The Crown Agents meanwhile had consulted Professor Simpson and Sir Alexander Houston and asked me to confer with these gentlemen, a proposal which I naturally declined, as up to that time Mr. Blount had acted as consulting chemist in connection with the work.

The use of lime appears to have reduced the organic content of the raw water to the original figure estimated by Mr. Blount and the filters consequently deal with the further reduction as they were designed to do.

It is not correct, therefore, to state that there were objections to the iron process or that multiple filtration did not afford a water of the standard desired. On the contrary, the reports of the medical officers for the Colony from 1914 onwards refer to the complete elimination of guinea-worm disease and other tropical ailments by filtration alone, long before the excess lime process was adopted or the water had been rendered (on paper) "epidemiologically" safe.

The filtering installation at Accra with the decanting reservoir over it was the first structure in reinforced concrete erected in the colony and was constructed under the personal supervision of Mr. W. F. H. Creber, M.Inst.C.E., late of the Derwent Valley Water Board, assisted by sixteen European foremen.

Yours faithfully,

June 12th, 1920. WALTER CLEMENCE.

# NEW BOOKS

## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

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**A Concrete Diary and Pocket Book.**

A particularly useful summary of the notable facts of the past year, together with much other information which is constantly required "in pocket form," is contained in the small *Agenda du Beton Armé*, 1920, published by V. Muzak, Brussels. This small volume, measuring only 6 in., contains a diary with spaces for engagements, a series of useful tables, such as one would expect to find in a technical pocket book, various formulæ, graphic calculations and charts respecting concrete and building construction generally, with numerous examples, a section on the strength of concrete and other materials, rules for concrete construction and so on. There are copious extracts from recent articles in the technical journals, showing new methods of using concrete as well as modifications of well-known methods and an excellent section on the raw materials used in connection with concrete.

Each of the more important sections of concrete construction—floors, beams, bridges, dams, foundations, piles, retaining walls, tunnels, mines and even ships—is dealt with briefly yet in a very practical manner, so that this small book should find a place on the desk or in the pocket of every engineer, draughtsman or architect who has to deal with concrete and whose knowledge of the French language is sufficiently good to enable him to make full use of the book and who does not mind working with metric weights and measures.

British engineers may not agree with some of the limitations or designs, but these are all, so far as we have been able to check them, in complete accordance with the general views of French engineers and with the official regulations respecting the use of concrete in France and its colonies.

There are more than 320 diagrams and useful sketches which greatly facilitate reference. The list of contents occupies 3½ pages, but unfortunately there is no index. The type is exceptionally clear and the volume is sufficiently well bound to stand ordinary usage for at least a year. It will continue to be useful long after the period for which it is issued, and if, as anticipated, this little diary is revised and published annually it will well deserve the welcome it is certain to receive from those for whom it is specially intended.

**Conference on Housing in France.**

The report of the Conference on housing which was held at Lyons last October has just been published,* and it serves once more to emphasise the many advantages of concrete in the construction of houses of all kinds, from the workman's cottage to the mansion. Among these advantages are some which, whilst indirect, are of great importance, such as the great saving in wood which is so readily effected when concrete is used, and the variety of design which is possible whilst using the same plan for the interior of the houses in a particular group.

Due stress was laid on the necessity of having the outside of the building waterproof, whilst the interior is porous and a sufficiently good conductor of heat to prevent condensation on the inside walls, but nothing very novel was suggested in this connection.

On the whole the Conference consisted in a review of much that is already familiar to our readers; there was a lavish use of illustrations for planning towns and villages, many of which appear to be just as rigid and stereotyped as in the past. Attention was called to the necessity of making domestic work as easy as possible, and it was suggested that a supply of hot water might be made available from a central source, much as cold water is now available in all except the smallest villages. A careful study of the report suggests that the French have scarcely realised the opportunities open to their special genius in improving the conditions of life, and the Conference largely contented itself with a cursory appreciation of American and of some British designs, and those present never seem to have realised that much of the slowness with which modern methods of building are associated in this country is largely due to a lack of that artistic *flair* which is usually so characteristic of French workmanship and design.

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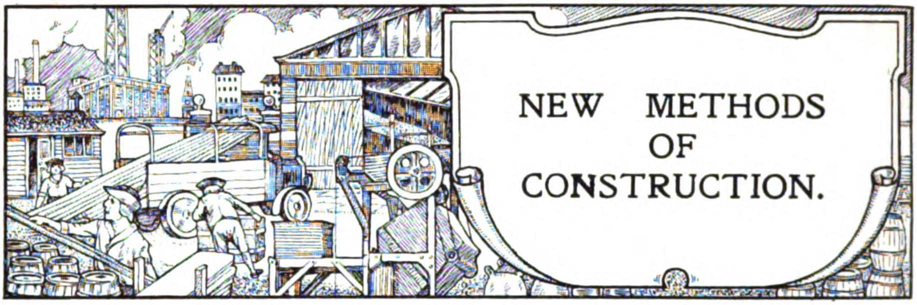
* Premier Congres de l'Habitation. Lyons: Imprimerie Noirclerc & Fenetrier.



# NEW METHODS OF CONSTRUCTION.

*In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—ED.*

## THE T. ELSON HARDY SYSTEM OF CONSTRUCTION.

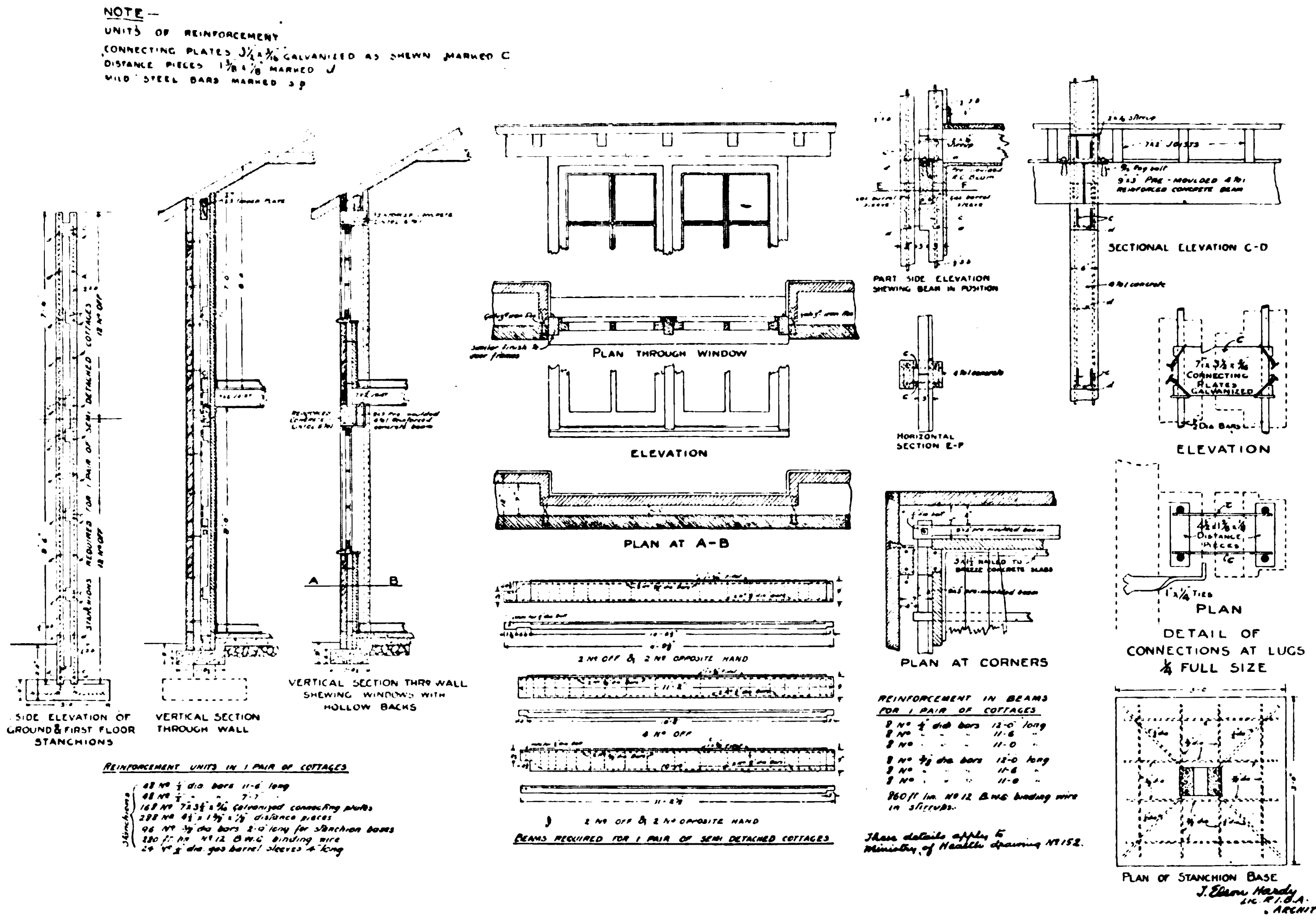
THE method of building to be described has been patented, and is primarily intended for use in the construction of cottages and working-class houses, as it is particularly applicable to buildings where the floor and roof spans are comparatively small, and the loads transmitted to foundations inconsiderable. We are informed that it is peculiarly suited for use at the present time, as its employment would ensure increased economy in building and rapidity of erection, combined, of course, with efficiency. The two former points are now of vital importance.

The illustrations show the use of what may be called "divided reinforced concrete stanchions" for use in connection with hollow external walls.

Whatever be the system of walling adopted in a small house, it will always form a heavy item of the total cost. It is on this item that it is proposed to economise. Solid walls in brick must be at least 14 in. thick to be really efficient; if 9 in. thick they have to be cement-rendered or rough-casted outside to be damp-proof, and even then are cold. In either case they are unduly heavy, and being weight-carrying throughout their whole length, unnecessary labour and material must be expended upon their foundations. The same objections apply to solid concrete walls, with the additional danger of internal condensation.

Hollow walls, whether in brick or concrete, are generally designed so that the inner half carries the weight throughout its length; it must, therefore, be at least 4½ in. thick, and even then requires an outer wall sufficiently strong to give it lateral support, by means of frequent galvanised iron or other ties crossing the cavity; so that the whole of the objections raised against the employment of solid walls will be found to apply to the use of hollow walls, though to a somewhat less extent. The method here described provides for the construction of external hollow walls, the whole of the weight from floors and roofs being taken by the reinforced concrete stanchions, the walls between the stanchions being merely for the purpose of excluding the weather and insulating the interior against ordinary changes of temperature. It is obvious that were the stanchions made solid through the thickness of the hollow wall there would be danger of condensation on the inner face of each stanchion. To remedy this defect, and to ensure a continuous air-space, the stanchions are constructed of two parts, an inner and an outer post—in other words the air cavity is continued through the stanchion itself.

The stanchions are of pre-moulded, reinforced concrete, each half about 6 in. by 3 in., with about a 3 in. space between, as shown. They may be moulded in one piece for the whole height, but this is not advisable, save in special circumstances, owing to the weight and liability to damage in handling if made too long. They should be constructed in heights approximating the heights of the floors, as shown; and their weight would be from 3 to 3½ cwt. in ordinary cases. Each half is reinforced by means


SIDE ELEVATION OF GROUND & FIRST FLOOR STANCHIONS
STANCHIONS REQUIRED FOR 1 PAIR OF SEMI DETACHED COTTAGES 12 No OFF
VERTICAL SECTION THROUGH WALL
VERTICAL SECTION THRO WALL SHEWING WINDOWS WITH HOLLOW BACKS
A
B
PLAN THROUGH WINDOW
ELEVATION
PLAN AT A-B
2 No OFF & 2 No OPPOSITE HAND
4 No OFF
2 No OFF & 2 No OPPOSITE HAND
BEAMS REQUIRED FOR 1 PAIR OF SEMI DETACHED COTTAGES
PART SIDE ELEVATION SHEWING BEAM IN POSITION
E
F
HORIZONTAL SECTION E-F
PLAN AT CORNERS
SECTIONAL ELEVATION C-D
7 x 3½ x 3/16 CONNECTING PLATES GALVANIZED
C
½ Dia BARS
ELEVATION
4½ x 1⅜ x ⅛ DISTANCE PIECES
1 x ¼ TIES
PLAN
DETAIL OF CONNECTIONS AT LUGS ¼ FULL SIZE
PLAN OF STANCHION BASE

NOTE—
UNITS OF REINFORCEMENT
CONNECTING PLATES 3½ x 3/16 GALVANIZED AS SHEWN MARKED C
DISTANCE PIECES 1⅜ x ⅛ MARKED J
MILD STEEL BARS MARKED S B

REINFORCEMENT UNITS IN 1 PAIR OF COTTAGES

Stanchions
48 No ½ dia bars 11-6 long
48 No ½ " " 7-7 "
168 No 7 x 3½ x 3/16 Galvanized connecting plates
288 No 4½ x 1⅜ x ⅛ distance pieces
96 No ⅜ dia bars 2-0 long for stanchion bases
280 ft lin No 12 B.W.G binding wire
24 No ⅝ dia gas barrel sleeves 4 long

REINFORCEMENT IN BEAMS FOR 1 PAIR OF COTTAGES
8 No ½ dia bars 12-0 long
8 No " " " 11-6 "
8 No " " " 11-0 "
8 No ⅜ dia bars 12-0 long
8 No " " " 11-6 "
8 No " " " 11-0 "
860 ft lin No 12 B.W.G binding wire in stirrups.

These details apply to Ministry of Health drawing No 152.

J. Eleon Hardy
Lic. R.I.B.A.
ARCHITECT.

of two vertical mild steel circular bars, ½ in. diameter, connected together in the concrete by means of flats marked *d*, having circular holes in same. These flats are slipped on to the bars from the ends, and are wired on at intervals of about 15 in. vertically. The connection between the inner and outer concrete posts is formed by means of two galvanised steel plates, marked *c*, about 3½ in. by $\frac{3}{16}$ in., resting at each end on similar flats to those mentioned and wired to the vertical bars as shown. They are embedded in concrete projections continued from the outer face of the inner posts to 1 in. from the inner face of the outer posts; they therefore have only 1 in. to span where unsupported by the concrete. The vertical bars of the ground-floor stanchions are left projecting at the base, those to the inner posts are afterwards bent inwards, and those to the outer posts outwards in the concrete foundation slabs, in which additional bars may be introduced as necessary. The first-floor stanchions also have all vertical bars left projecting at the base—in this case only 1 in.; these fit into gas-barrel sleeves cast in the top of the lower stanchions. The beams supporting floors are of pre-moulded reinforced concrete, and are fixed in the air-space between the inner and outer walls. The methods by which these beams are fixed to stanchions, floor and roof are clearly shown in the accompanying details, and will be seen to give both transverse and longitudinal strength.

For fixing the outer walls to the stanchions, galvanised iron ties, as shown—passing at the back of the outer post and built into the wall-joints at intervals vertically to suit the particular wall adopted—would be provided. Additional ties are also provided at each side of all door and window-openings.

The advantages claimed for this method of construction are:—

1. Adaptability to suit architectural characteristics of any locality, and also as to use with the materials most readily obtainable.
2. Ease and rapidity of erection.
3. Economy of construction.

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## MEMORANDA.

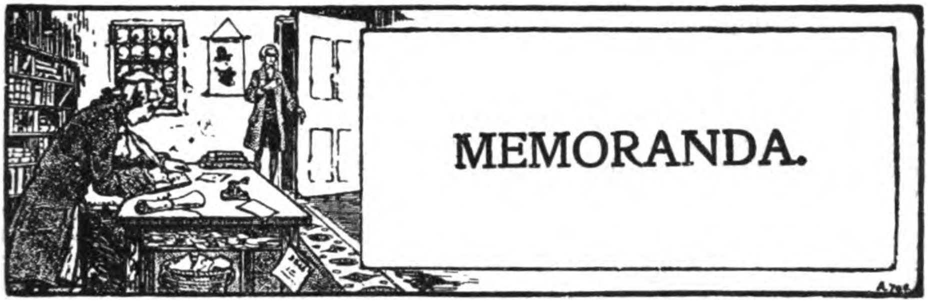
**Reinforced Concrete Bridge Across the Connecticut.**—One of the largest bridges to be built in America since the war, says the *Engineering News Record*, is to be started shortly at Springfield, Mass. The bridge is divided into two portions. (*a*) The river bridge, consisting of seven reinforced concrete arch spans, with a total length of 1,129 ft. between the abutments, and a clear width of roadway of 60 ft., and sidewalks 10 ft. wide on either side. Each span consists of five two-hinged arch ribs, two spandrel walls, columns, and a floor system—all of reinforced concrete. (*b*) A reinforced concrete viaduct having a total length of 300 ft., consisting of nine spans, eight of which have a length of 31 ft. clear.

**Concrete Wine Tanks.**—Some concrete wine tanks have been constructed in South Africa. These tanks cost $7,305 for a total of 22 sections without any reinforcement; and the concrete mixture is a 1 : 1½ : 3 mix. The prices for material and labour are:—

| | $ |
|---|---|
| *Materials:* | |
| Cement, bag of 2·3 cu. ft. | 2·04 |
| Sand, cu. yd. | 1·25 |
| Stone, cu. yd. | 2·04 |
| *Labour:* | |
| Foreman, per day | 4·00 |
| Carpenters, per day | 3·75 |
| Labourers (Native) | 1·04 |

Concrete U.S.A.

**Maxwelltown: Mill.**—Fully £18,000 will be spent on building extensions to Rosefield Tweed Mill, Maxwelltown. A reinforced concrete structure is planned.

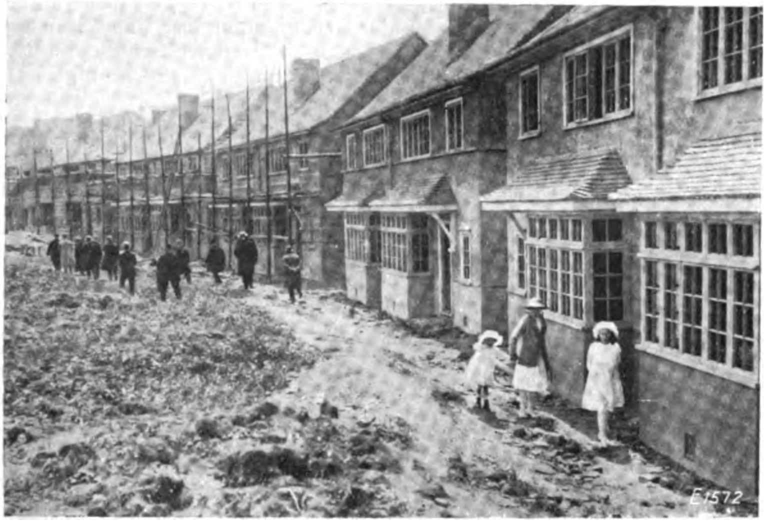


# MEMORANDA.

*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**International Housing Congress.**—A party of delegates attending the International Housing Congress at Westminster, including the Belgian Minister, M. Bertrand (vice-president of the Belgian Parliament), and most of the Belgian representatives, made a special tour of inspection round various housing schemes which are being carried out in this country. Great interest was taken in the scheme at Wembley Hill, where Messrs. Callow & Wright are developing an estate of some 400 acres, as well as in the neighbouring estates of the Metropolitan Railway Co., at Wembley Park and Neasden, all of which are being developed on the same system.

Of the 40 houses at present under construction at Wembley Hill seven have been completed up to the present, and each of these has already been sold. Two types of houses are being constructed, each type, however, including the same number of rooms—parlour, living-room, kitchen, scullery, and three bedrooms, with a bathroom on the first-floor. The walls are built of Winget blocks with an aggregate of ashes (breeze) from the electricity works just by. The party walls are built of solid 16 in. × 9 in. × 9 in. blocks, but having a core hole through them; and in making these blocks the breeze is used as received from the electricity works. In making the internal partition slabs, which are 2½ in. in thickness, the breeze is put through a screen and only the fine material used. The external walls are built with a continuous cavity, the inner leaf being 4 in in thickness, and the outer leaf 3 in. in thickness, tied together with galvanised iron ties. The external walls are rendered, and in some cases colour-washed. Gas is provided for cooking, and electriciy for lighting.



CONCRETE HOUSES AT NEASDEN.

On the Metropolitan Railway's estate at Neasden some 40 houses under construction were seen in various stages, some just started, others practically finished. The accommodation is much the same as at Wembley, though the arrangement is somewhat different. The walls are built with a continuous cavity, but both the inner and outer leaf is 4½ in. The proportion and material in the blocks are similar to those at Wembley. The builders (Cyclopes Construction Co.) who are also making the concrete blocks, are getting good outputs from their machines, the figure averaging about 40 pulls per hour, or 160 blocks, 16 in. × 9in. × 4½ in., per hour.

In order to see how houses thus built have " weathered," and otherwise stood the test of time, the delegates subsequently visited a number of homes in various parts of Kent, including estates at Wrotham and Otford, where houses of concrete blocks and slabs have been occupied for years. In some of these houses the blocks have been made from an aggregate of chalk and sand, with results which have proved in every way satisfactory.

**Concrete in Waterworks Construction.**—Mr. A. C. Irwin, in the *Canadian Engineer*, summarises the use of concrete in the construction of dams, reservoirs, pressure-pipes, tanks, filters, pump-houses and other water-holding structures.

The concrete pressure pipe is a practical success. The reinforced concrete pressure pipe-line constructed as a part of the Gunpowder water-supply for the city of Baltimore consists of 5,000 ft. of 108 in. diameter pipe and 3,000 ft. of 84 in. diameter pipe. This line carries 120,000,000 gallons daily, and when tested under a head of 85 ft. the leakage in 24 hours on the entire line amounted to 13,000 U.S. gals., or less than 2/100th of 1 per cent.

Obviously, if concrete pipe can be constructed uphill and down, and with curves in an out, to withstand over 100 ft. head of water pressure, there would be no difficulty in building a standpipe of like height, and, in fact, many examples are in existence of concrete standpipes of much greater height than 100 ft. The Fulton standpipe, at Fulton, N.Y., is 100 ft. high to overflow, and is 40 ft. in diameter. The circular concrete tower and tank at Middleboro, Mass., is 123 ft. high. The concrete cylindrical tower and tank of the Central Georgia Railway, at Savannah, is 188 ft. high.—*Technical Review.*

## CONCRETE AND HOUSING SCHEMES.

The Ministry of Health announces that up to the beginning of June contracts had been placed by local authorities and public utility societies for the building of 8,641 houses by special methods of construction, of which 1,917 had been commenced. Of these totals about two-thirds are of concrete construction. At the same date certificates had been granted approving plans of 533 concrete houses to be erected by private persons with the aid of the Government grant.

Hunslett.—The Urban District Council has placed a contract with Messrs. Mason & Son for the erection of 250 houses on the " Léan " system of concrete construction.

Leeds.—The Town Council has accepted the tender of the Waller Housing Corporation for the erection of 500 houses on the Cross Gates Estate at £788 4s. 2d. per house of type " A " houses, and £838 14s. 2d. per house for type " B " houses.

Macclesfield.—The Macclesfield Housing and Town-Planning Committee has provisionally accepted the tenders of Messrs. Sharples & Atherton, of Altrincham, for the erection of concrete houses, as follows :—Type " A " houses, £720 each ; type " B " houses, £860 each.

Manchester.—The Corporation has accepted the tender of Messrs. Walter Jones & Sons, Ltd., of London, for the erection of 300 houses on the " Clare-Interloc " system of concrete construction on the Catterick Hall Estate.

Newcastle-under-Lyme.—The Newcastle-under-Lyme Rural District Council has accepted the tender of Messrs. Brammer & Patrick, of Hanley, for the erection of eight concrete houses for the sum of £8,416.

Rotherham.—The Town Council has accepted the tender of Messrs. F. Hopkinson & Co., of Worksop, for the erection of 50 houses on the " Dorman Long " system—15 houses at £790 each, and 35 at £900 each.

Sheffield.—A pair of houses are to be erected on the " Dorman Long " system on the Stubbin Estate for the Sheffield Town Council at a cost of £945 each.

Shoeburyness.—The Urban District Council has under consideration the tender of the Simplex Construction Co., Ltd., Onslow Mills, Yiewsley, Yorks, for the construction of 20 houses in pairs in Ness Road and Waterworks Road.

Welwyn.—All the houses to be built by Welwyn Homes, Ltd., at the " second garden city " of Welwyn, are to be built on the " Léan " system of concrete construction. The contract for the work has been placed with Messrs. Trollope & Colls, Ltd.

## OTHER TENDERS.

Concrete Factory at Leicester.—The tender of Messrs. Wm. Moss & Sons, Ltd., of Loughborough, at £58,000, has been accepted for the erection of a reinforced concrete factory at Leicester for the Imperial Typewriter Co. The architects are Messrs. Pick, Everard & Keay, of Leicester.

Dundee Power Station.—The Yorkshire Hennebique Construction Co., Ltd., has been awarded the contract for the reinforced concrete foundation work at the Carolina Port Electric Generating Station of the Dundee Corporation for the sum of £23,042.

## ROAD WORK.

Work is now in progress on the laying of a concrete raft measuring 7,000 super yards for two new factories being built by Messrs. Watney, Combe, Reid & Co. The reinforcing is on the Walker-Weston System, comprising an interlocked double-layer framework of a depth of 5½ in. between top and bottom layers for a 9-in. depth of concrete. The Walker-Weston Co., Ltd., invite engineers to view the reinforcement, which is being made and laid on site of works. The whole of the work is under the supervision of Mr. M. T. Saunders, architect and surveyor to Messrs. Watney, Combe, Reid & Co., Ltd.

## CORRESPONDENCE.

### Regional Surveys conducted by Schoolmasters.

To the Editor of Concrete and Constructional Engineering.

Sir,—One of the latest phases of education is the Regional Survey, which has been adopted by some of the more progressive schools.

The surveys are made under the direction of an enthusiastic master, who explains to the pupils, as they halt from time to time in their tramp along the country lanes and the streets of towns, how England has evolved from the earliest times. These teachings include such subjects as the evolution of roads from cowpaths, the formation of rivers, the strata of the earth and its bearing on vegetation and health, and, what will particularly interest the readers of this journal, the study of architecture, both domestic and ecclesiastical.

The Natural History Society connected with the Friends' School at Saffron Walden visited Bishop's Stortford early in June, and I had the great pleasure of entertaining the pupils and of listening to remarkably instructive discourse. It was interesting to hear the master describing the progress of this ancient town as he pointed out the features of the flint-walled church, the quaint market square, with its covered-in structures, the remains of the Bishops' palace, which is near the old ford over the River Stort, the half-timbered inns, together with the ruins of the Norman castle.

Such lessons are bound to benefit the country and especially the art of architecture, for it is impossible for anyone to study the various styles of buildings and then be satisfied with the bastard architecture which is so prevalent in England.

Any scheme which inculcates a knowledge of architecture is bound to benefit the architect. I am sure that if the architectural societies were to move for a furtherance of this scheme amongst schools and colleges they would be helping themselves as well as making England a more beautiful country.

Bishop's Stortford. J. H. Kerner-Greenwood.

## TRADE NOTES.

**Great War Exhibition, Crystal Palace.**—At the above exhibition an interesting exhibit is that of Messrs. Vickers, Ltd., of Vickers House, Broadway, Westminster (Stands 151-160), who are showing their machinery, including their concrete brick and tile machines, to which reference has been made in these pages. Engineers' small tools of every description are also exhibited.

A number of firms associated with Messrs. Vickers are also exhibiting their specialities on these stands.

**Trent Concrete, Ltd. : Alterations to the Colwick Works.**—For the past twelve months the building of concrete houses has created considerable controversy among the general public, not only in Nottingham but throughout the country. People have been, and still are, under the impression that, with the introduction of the numerous labour-saving schemes, it is possible to build a concrete house in a few days, and at a very small cost. It is quite true that a concrete house does not take anything approaching the time it occupies to build one of brick, but as far as the cost is concerned the problem has yet to be solved. A test scheme of building two houses on a site selected in old Colwick has been decided upon, after which the public will be acquainted with the whole facts, and be able to enter contracts with Trent Concrete, Ltd., for the building of dwellings.

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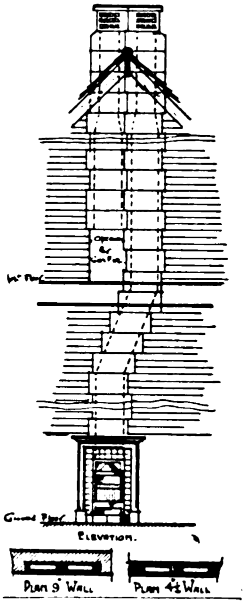
There is no doubt that within the next few years big schemes of building concrete houses will be carried out, and in order to meet with the demands of contractors the Trent Concrete, Ltd., are making extensive alterations at their works in Colwick. Already a new railway is being laid at Colwick, which will link up with the lines of the Great Northern Railway Co. at Netherfield, and in the course of a few weeks it is proposed to instal a steam shovel at the works for the purpose of filling the railway wagons. By this means contractors will be able to have their supplies delivered in the shortest possible time.

In addition to the many other alterations there will be a new gravel mill erected, and when completed it will be possible to turn out sufficient material to meet all requirements.



**Cast Concrete Gas Flues and Terminals.**—The increasing use of gas for heating purposes in our dwellings has led the Nautilus Fire Co., Ltd., of 60, Oxford Street, W.1, to make a number of experiments with a view to evolving a satisfactory system of gas flues and terminals. The system is illustrated in the accompanying diagram, hollow concrete blocks being used to build up the flue. The company have a full-sized section of a house, erected on the principles advanced, at their show-rooms at 60, Oxford Street, W., for the inspection of all who are interested in the use of gas for the heating of our dwellings. It is estimated that a saving of £30 per cottage can be effected in housing schemes by adopting this system.

**" Helyxa " Bars.**—Our attention has been called to the " Helyxa " steel bars, of which we give a few particulars below.

A very prominent feature of this bar is its square section, with four projecting ribs at the corners, which, it is claimed, gives a higher ultimate strength and yield

*The book you must have—*
*no other will do*

The CONCRETE ENGINEERS' HANDBOOK

By GEORGE A. HOOL, S.B., Associate Professor of Structural Engineering, University of Wisconsin, author of three volumes on "Reinforced Concrete Construction," and Nathan C. Johnson, M.M.E., Consulting Concrete Engineer, New York City; assisted by S. C. Hollister, M.S., with chapters by Harvey Whipple, Editor of "Concrete,"; Adelbert P. Mills, Assistant Professor of Materials, Cornell University; Walter S. Edge, Consulting Engineer to Concrete Steel Co., New York; A. G. Hillberg, Consulting Hydraulic Engineer, and Leslie H. Allen, Aberthaw Construction Co. 800 *pages*, 6 *by* 9, *fully illustrated, flexible binding.* Price, net, 36/-

A compact reference book containing tables, formulæ and data on plain and reinforced concrete. It is up-to-date, and covers the entire field thoroughly. It contains a wealth of valuable material which has been collected by a staff of specialists in different branches of concrete construction. In the presentation of material graphically, the choice of illustrations and the special flexible binding, the book is designed for efficient use on the desk and drafting table.

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point than ordinary rounds, although the bar itself is made from mild steel, to British standard specification (28-32 tons per sq. in.).

The bar is square in section. After it has been rolled, it is twisted cold in special machines, the number of twists per foot being made to vary with the size of the bar, as the result of exhaustive experiments.

The strength of the bar in direct tension is 39-40 tons per sq. in., and the yield point 32 tons, whilst the reduction of area and elongation are ·43 per cent. and 10 per cent respectively. The bar is of uniform section throughout.

From the particulars before us we learn that Messrs. David Kirkaldy & Sons tested to destruction three beams reinforced with " Helyxa " bars. The test consisted of a centrally applied load on a beam of 10ft. span.

The concrete failed at a load of 9·4 tons, which produced in the steel a tensile stress due to bending of 100,000 lb. per sq. in. without any fracture whatsoever.

Of the beams subjected to testing one had bars hooked at the ends and the others plain ends. In both cases the load at which the beams failed was the same, and the adhesion equally good. The makers claim that the " Helyxa " bar requires no hooking or fishtailing.

The results of tests justify a working stress for the steel in tension due to bending of 23,000 lb. per sq. in., which would still give a factor of safety of more than 4.

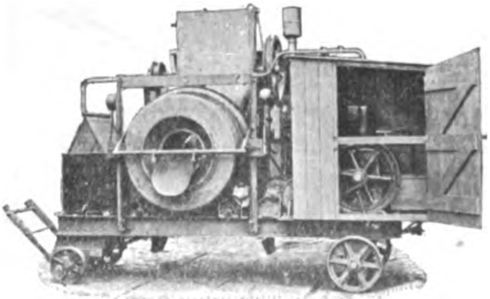
The British Steel Bar Co., Ltd., of 17, Victoria Street, Westminster, S.W.1, state they are in a position to supply the bars promptly.

## PATENT APPLICATIONS.

142,227.—C. Pegram : Metal skeletons applicable to reinforced concrete buildings.
142,285.—P. H. Allnatt : Building blocks.
142,328. Reinforced concrete construction.
142,526.—S. P. Henman : Concrete roofs and floors.
142,594.—H. A. Hamilton : Concrete walling (blocks).
142,697.—J. Ryan : Apparatus for moulding and trimming building blocks.
142,958.—G. A. Bravin : Concrete.
142,965.—F. B. Smith : Concrete slab houses.
142,997.—R. T. Macarthur : Building blocks.

## NEW COMPANY REGISTERED.

ILFORD PATENT STONE CONSTRUCTION & SUPPLY CO., LTD. (168,291).—Registered June 15th, 1920. 75, Bedford Road, Ilford. To construct buildings in concrete and patent stone. Nominal capital, £10,000 in 10,000 £1 shares. Directors : T. V. Haigh and R. E. Solomon. Qualification of directors, 250 shares ; remuneration to be voted by company.



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# CONCRETE AND CONSTRUCTIONAL ENGINEERING

**THE OFFICIALLY APPOINTED JOURNAL OF THE CONCRETE INSTITUTE**

**AUGUST 1920. VOL. XV. No. 8.**

***A MONTHLY JOURNAL for Engineers, Architects, Surveyors, and Contractors, and all interested in Cement, Concrete, Reinforced Concrete, Fire-Resisting Construction and Structural Steel***

*ISSUED MONTHLY*

## CONTENTS.

**Editorials.**

**Whitby Harbour Extension Works.**
By JAMES MITCHELL, M.Inst.C.E., etc.

**The Stability of Thin Walls, and Heat Transmission through Thin Walls.**

**Concrete Cottage Construction.**
The Bognor Hutting Scheme.

**Specification for Cement Concrete Buildings.**

**A New 1,000 Ton Elevated Coal Bunker.**

**The Concrete Section at The Royal Agricultural Show, Darlington.**

**Recent British Patents Relating to Concrete.**

**Concrete in Theory and Practice.**
Reinforced Concrete Simply Explained. By Dr. OSCAR FABER, O.B.E., D.Sc., etc.

**Economy in Concrete Road Construction.**

**A Large Pile-Driver.**
By R. N. STROYER, M.I.M.E.

**Gravity Distributing Plant for Concrete Work.**

**New Books.** **The Foreign Press.**

**New Methods of Construction.** **Memoranda.**

THE CONCRETE INSTITUTE:
Monthly Notes, by the Secretary.
The Ventilation of Concrete Buildings, by Edward L. Joseph, M.I.E.E., etc.
Abstract of Paper read at the 96th Ordinary General Meeting.

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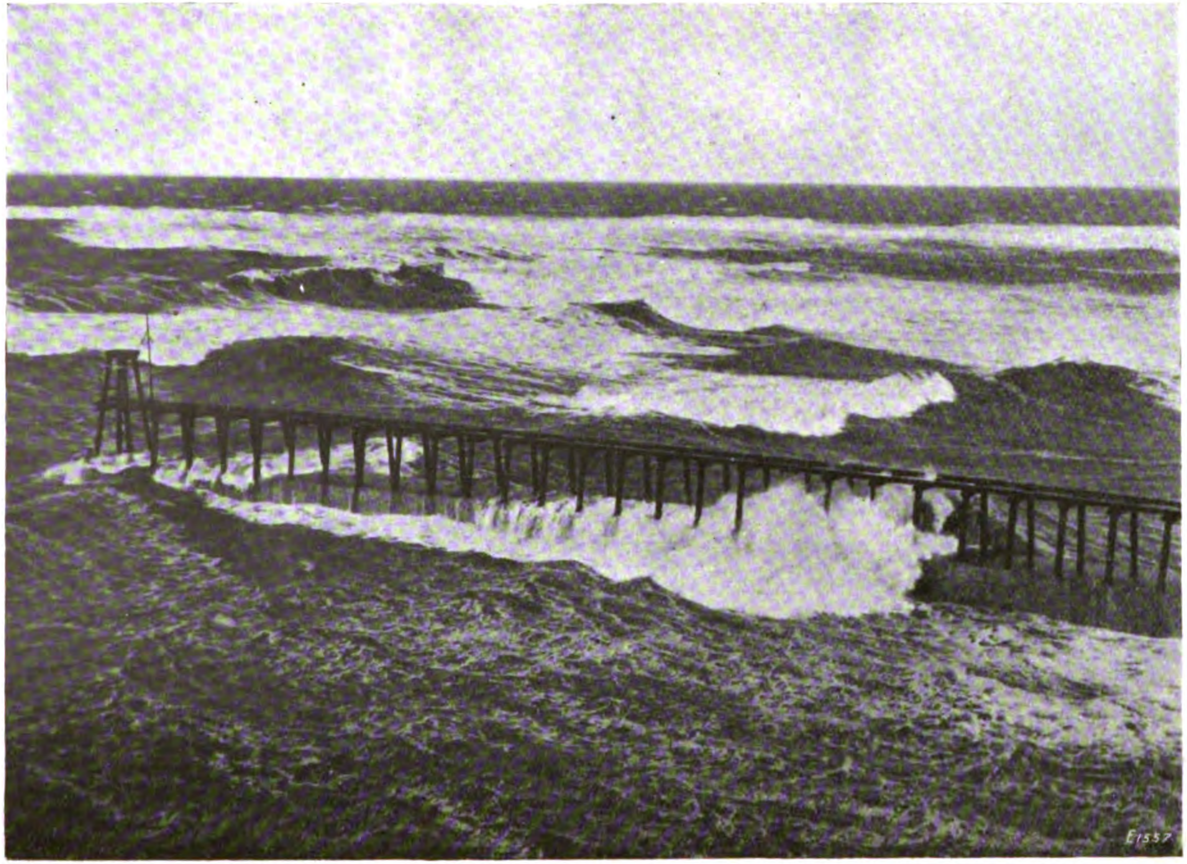


New East Pier (nearing completion) during a heavy swell.
WHITBY HARBOUR EXTENSION WORKS.
(*For Description see p.* 517.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XV. No. 8. LONDON, AUGUST, 1920.

# EDITORIAL NOTES.

## APPROVED METHODS OF CONSTRUCTION.

THAT concrete possesses qualities that make it pre-eminently suitable as a material for the construction of small houses and cottages is becoming ever more widely recognised. And as its use becomes more general, so will its limitations become known and its weaknesses be guarded against. Before the war concrete was only used tentatively as a cottage building material, and, as is inevitable under such circumstances, certain mistakes occurred, chiefly through lack of experience, which tended to bring the material into discredit, the effort in this direction being made either by those who were merely prejudiced against any form of novelty in building, or by those against whose interests it was that a new and competing material should assert itself. Thus disproportionate emphasis was given to the fact that in certain cases walls sweated, in others the houses were made uncomfortable by reverberation, and some were not entirely weather-proof. As experience in the use of concrete for the cottage grows so will these mistakes tend to become rarer, and even now it is possible to look ahead to the day when every builder and contractor, however small may be his business or limited his resources, will, nevertheless, be as accustomed to build in concrete as in brick or stone, and a faulty concrete dwelling will be no more frequent than a faulty building in these hitherto more familiar materials.

It has been almost possible to trace the growing confidence that is being felt in concrete by the continual concessions in its favour that are being made by the Ministry of Health. These have now received certain further extensions. The issue of *Housing* (the official publication of the Ministry of Health) of July 5th contains a list of methods of construction which may be employed by persons desirous of obtaining the grant under the Housing (Additional Powers) Act, 1919. This list, which is additional to the various patent systems that are from time to time receiving approval, allows of certain reductions in the thickness of walls and allows cement tiles to be used as a roof covering. But with regard to the latter, the Standardisation Committee suggests that a local authority intending to use them should obtain a guarantee from the makers that the tiles will form a durable and strong roof covering. A very wise precaution, we think.

Of the various special systems of construction that have been passed by the Standardisation Committee by far the largest number comprise some form of concrete construction. The loud but ephemeral outcry that took place in the lay press in September and October of last year on behalf of the timber house has proved abortive. The reason is simple. Timber construction is not indigenous to the country. There are many examples of timber houses in various parts of England, but the total number is quite insignificant. Concrete, however, is entirely indigenous, and it is, therefore, but right that it should become a nationally recognised system of building, gradually establishing a tradition of workmanship and of design; moreover, it is a material particularly consistent with modern ideas of health, sanitation and prevention of fire risk. We feel perfectly convinced that the growing confidence which the Ministry of Health and local authorities generally are placing in concrete is entirely justified. As for the æsthetic aspect of the concrete house, we have repeatedly shown examples in this journal whose range has been extensive, both in style and in locality, and which contain amongst them sufficient charm to satisfy the most fastidious.

## COKE-BREEZE CONCRETE.

IN the "Specifications for cement concrete building approved by Standardisation and Construction Committee of the Ministry of Health," which we reproduce elsewhere in this issue, we read with astonishment that while clinker is, with certain safeguards, recognised as a suitable aggregate for concrete building purposes, "coke breeze will not be allowed," either for making blocks and slabs or for concrete *in situ*. We wonder why.

It is now a well-established, and, we thought, an accepted fact that coke-breeze, under certain conditions, was entirely suitable for many kinds of concrete work, notably for partition walls and for the interior leaves of cavity walls; indeed, many experts advise the use of this material for such purposes, since it possesses advantages which cannot justly be ignored, among them being its porosity, whereby the condensation difficulty is eliminated, the possibility is afforded of driving nails into it, and, a porous concrete being a poor conductor of heat, the internal temperature of the building is rendered more equable. Of course, these advantages are also offered by clinker, but why coke breeze should be barred passes our comprehension.

True, care must be taken that the material *is* coke breeze, and that it does not contain particles of unburnt material or other deleterious matter, but here again the same proviso applies to clinker.

We notice further that in the specifications for external work clinker concrete may be employed and may be made weatherproof by being finished on its outer face with "a coat of cement rough-cast not less than ½ in. thick." While we do not advocate the use of coke-breeze for external work, yet, if such a method is regarded as satisfactory with clinker, we fail to understand why coke-breeze should be totally forbidden for all purposes.

Still another advantage of coke-breeze over the majority of aggregates is that it ranks high as a fire-resisting material, and surely this is of importance in the case of dwelling houses and is a property which should give it a strong claim to consideration.

We are of opinion that the Ministry has been ill-advised in prohibiting entirely the use of a material which, with proper precautions as to purity, and strict limitations as to the purpose and manner of its employment, constitutes a useful aggregate for Portland cement concrete building.

## THE CONSISTENCY OF CONCRETE FOR ROAD WORK.

It has been conclusively proved that the amount of water with which concrete is mixed is the most important factor in its ultimate strength, and that any water additional to that required to produce a workable mass not only results in a poorer concrete but also wastes cement. The strength of concrete is also the measure of its wearing qualities, and thus the use of a mixture of the right consistency is a big factor in road work. This fact is realised in America, where strict supervision at the mixing plant is regarded as one of the first essentials in the production of good results. A method of testing the consistency of concrete adopted by the Illinois State Highway Department was described by Mr. W. P. Near, City Engineer of St. Catherine, Ontario, in a paper read before the recent Canadian Good Roads Convention. The system is as follows:—A thin metal mould in the form of a truncated cone, 12 in. high, 8 in. across the base and 4 in. across the top, is filled with concrete, which is lightly tamped with a rod as it is placed in the mould. As soon as it is filled the mould is removed and the height of the cone-shaped mass is measured. The amount of diminution in the height of the concrete as compared with the height of the mould is the measure by which the consistency and the mixture is judged. For concrete to be finished with a mechanical tamping machine the settlement should be not less than ½ in. and not more than 1 in.; if the concrete is to be finished by hand methods the settlement may be as much as 1½ in. With a method such as this the concrete for the whole of the job can be judged by a comparison with that which has been tested and found to be of the right consistency. This method is stated to have proved quite successful in the United States, and may be of value to road engineers in this country. No doubt, however, many of our readers have adopted other methods of testing the consistency of concrete without the use of laboratory apparatus, and in view of the importance of the matter (the United States Bureau of Standards has established the fact that an excess of from 10 to 15 per cent. of water over that actually required reduces the strength of concrete by nearly 50 per cent.), we would invite them, in the interests of "better concrete," to send particulars for publication in our columns, so that they may become widely known.

## ROAD CONSTRUCTION IN AMERICA.

We give below some interesting notes regarding road construction in America, which have been sent to us by a correspondent.

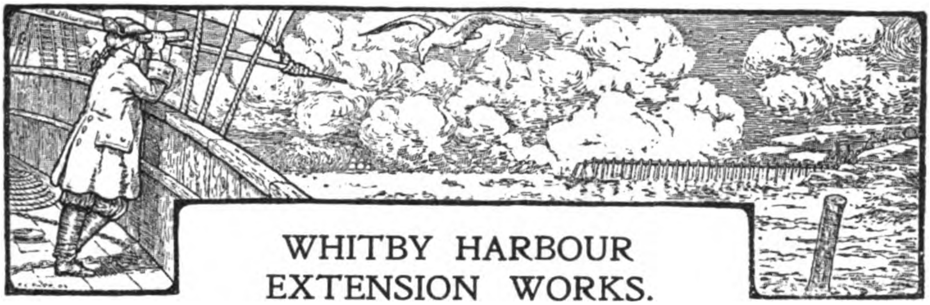
It is interesting to note how the concrete road in America has developed alongside the increasing use of the motor-driven vehicle. This point is best illustrated by the following figures:—

At the close of the year 1909 there were six miles of concrete road in all the United States. At the end of 1919 there were over 11,000 miles of concrete road. During the same period the automobile traffic had increased from 127,731 cars to 8,000,000.

Motor cars demand a smooth rigid road. This was not the case when the horse was the motive power. Horse-drawn travel compacts dirt and gravel roads, while motor traffic disrupts these same roads. The cost of driving intricate and expensive motor vehicles is correspondingly more expensive on poor roads.

The farmer, who, in the United States, was at first strongly opposed to motor-driven vehicles, soon discovered they were valuable aids to him in his work, and thus the rural communities began to demand concrete roads, and farmers are consistent supporters of this type of road.

As is well known the State of California builds her roads almost exclusively of concrete. In this State alone 2,500 miles of roads are made of concrete. In the case of the " Ridge Route," a Californian concrete highway, covering a stretch of 30 miles and costing about 1,200,000 dollars, it has been estimated that with the heavy traffic passing over this road the total cost of building would be absorbed in less than 200 days by the saving in gasoline, tyres and upkeep on the vehicles passing over it.



# WHITBY HARBOUR EXTENSION WORKS.

**By JAMES MITCHELL, M.Inst.C.E., M.I.Mech.E.**

THE quaint old seaport of Whitby lies on the north-east coast of Yorkshire at the mouth of the River Esk, and has a population of about 12,000. At one time it ranked seventh among British ports, but owing to the change from sailing to steam ships, the lack of the money necessary for adequately coping with the rapidly increasing size of vessels, and the decay of several of its chief industries, such as shipbuilding and whale fishing, it has lost its former rank.

With the aid of a grant from the Government, however, an important scheme of harbour improvement was completed shortly after the outbreak of war, and there is good reason for hoping that a new era of prosperity may lie ahead for the town. As a fishing-port Whitby has the advantages of a salient position on the coast, proximity to excellent fishing grounds, and a deep-water harbour having railway communication at quay-level.

With its various piers and quays, built during different periods (*Fig.* 1), Whitby is a good example of a river-mouth harbour, and illustrates the various stages of evolution of that type. It faces nearly due north, there being a sandy beach on the west side for a distance of about 3 miles, while the coast for many miles to the eastward is bare and rocky. The materials of the beach tend to travel eastward, with the result that before the new works were carried out there was a large sandbank at the harbour entrance, extending both inwards and outwards from the pierheads, and drying several feet at low water. At intervals floods in the river enlarged the channel through this bank, and storms lowered the level of its surface, but during fine weather the sand tended to accumulate again, and during droughts the channel nearly disappeared. Even in moderate weather the seas breaking on this bank were so dangerous for fishing-boats that it was a common occurrence for the lifeboat, as a measure of precaution, to be in attendance for some hours during the period of low-water. Inside the harbour the range during storms was so great that vessels and boats were obliged to go above the swing-bridge for safety. In addition to being shallow the entrance-channel was narrow and tortuous. At low-water of spring-tides its depth at the pierheads was about 2 ft., and from the pierheads to the harbour quays it averaged only 1 ft. The course of the channel was close to the outer arm of the East Pier, from which it took a sharp bend up to the Scotch Head jetty.

In order to remedy those defects, the following works have been carried out:—

(*a*) Two new piers, each 500 ft. long.

(*b*) A new fish-quay, 700 ft. long.

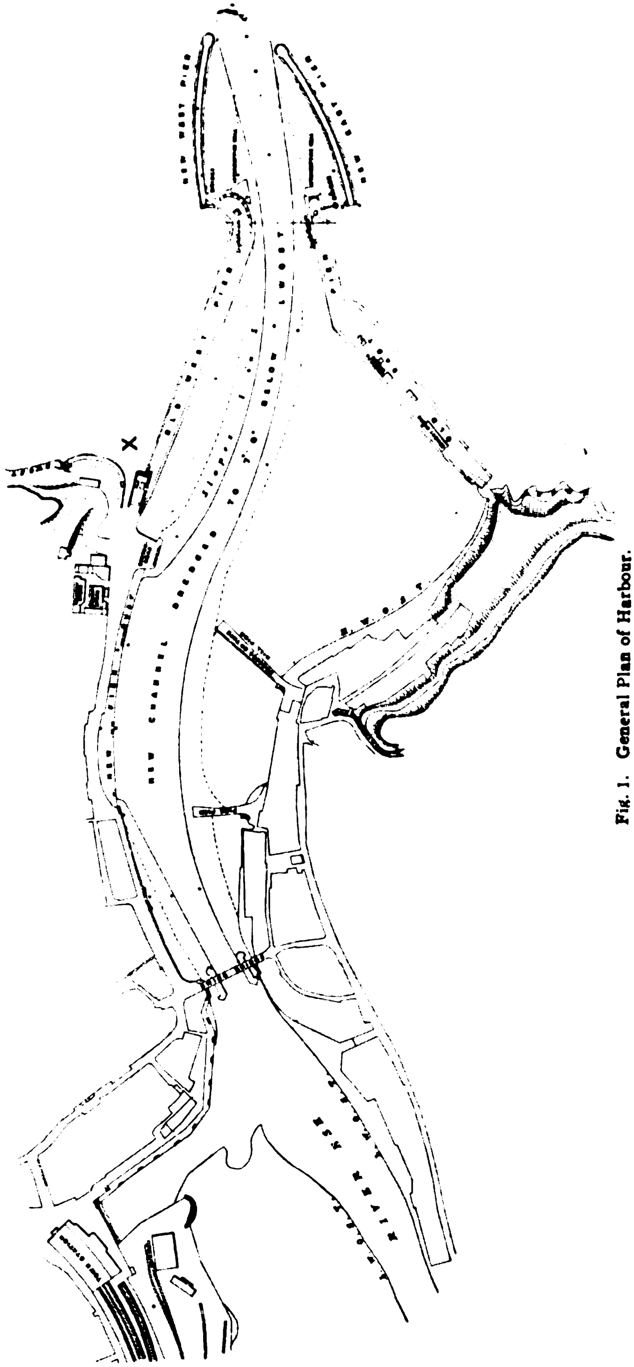


Fig. 1. General Plan of Harbour.
*Note.*—Positions of trial borings shown thus •.

WHITBY HARBOUR EXTENSION WORKS.

(*c*) An improved entrance-channel and general deepening of the harbour up to the swing-bridge, the depth of water provided throughout being 7 ft. at low water of ordinary spring-tides. (The range at spring-tides is 15 ft.)

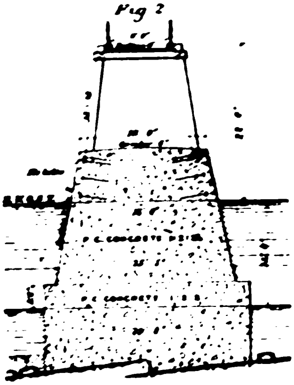
### THE PIERS.

The new piers—the centre-lines of which are curved to a radius of 1,000 ft.—overlap the old pierheads, and thus form an outer harbour, within which the entering waves may expand in width, with a corresponding reduction in height before they reach the old pierheads. Openings are left between the old pierheads and the landward ends of the new piers, and, in conjunction with intercepting-jetties constructed at the old pierheads, those openings form wave-traps, by means of which more than 50 per cent. of the width of the waves is cut off and turned outside the harbour again. In the gap between the old and new west piers a concrete glacis, extending up to the level of 4 ft. below high-water, was formed for the purpose of preventing the passage of sand from the beach into the harbour.

The new piers are founded throughout upon hard shale rock. They consist of monolithic concrete structures extending to a height of 7½ ft. above high-water of ordinary spring tides and surmounted by timber superstructures, the level of the roadways being 22 ft. above high-water (*Figs.* 2 and 3). The cross sections of the two piers were intended to be the same, with the exception of the width of the substructure of the concrete portion. In view of the use of the west one as a public promenade, however, it was afterwards decided to increase the width of its roadway from 8 ft. to 13 ft., which was effected by making the timber uprights vertical instead of battered as in the east one, the roadway of which was not altered. At the outer end of each pier there is a timber lighthouse carrying a fifth-order revolving electric-portlight.

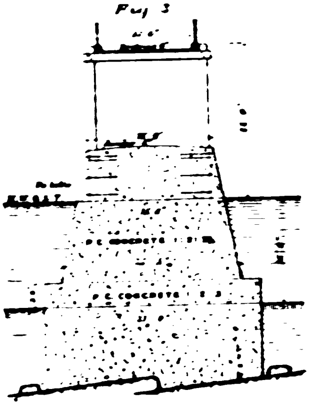
It was originally intended that the piers should be constructed by means of timber trestle-work, on which would be carried the necessary cranes, railways, etc., and which would afterwards be incorporated in, and form a portion of, the permanent structures. In view, however, of the great exposure of the site, and of the difficulties involved in driving piles into the shale so as to form a staging of adequate strength, the Contractors proposed the use of a novel type of locomotive stage (*Figs.* 4, 5, and 6), which they had devised and used with great success for work in a very exposed position at Peterhead Harbour in the north of Scotland. (The Peterhead stage was afterwards used at the Admiralty Harbour, Dover.) This proposal was agreed to, and the timberwork curtailed accordingly, by dispensing with piles and supporting the roadway by means of uprights imbedded for a length of 7 ft. in the concrete structure. Two locomotive-stages were built, the two piers being constructed simultaneously. Each stage consisted essentially of two rectangular lattice-work steel frames, an outer A and an inner B, the inner frame being wide enough to span the foundation of the pier. Each frame was provided with four 16-in. square Oregon-pine legs or spuds, which moved in vertical guides as shown. To the top of each spud was fixed a vertical screw which passed through a combined wormwheel and nut attached to the frame. Each of those nuts was rotated by an electric motor, and by those means the spuds could be raised or lowered. A third frame—the rolling-frame C—was

Fig 2

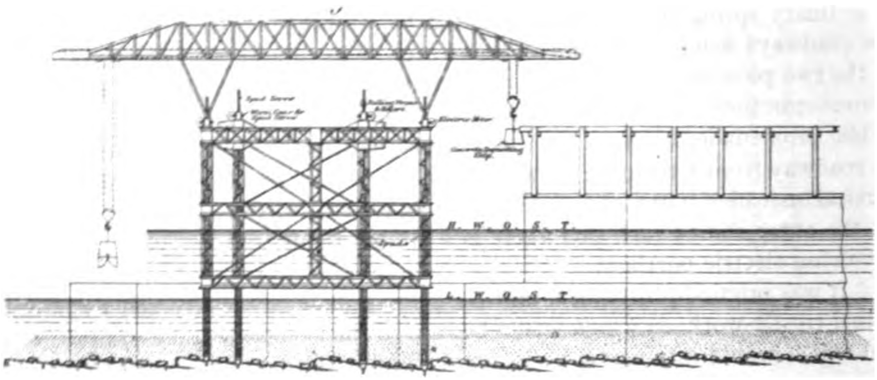


CROSS SECTION OF EAST PIER

Fig 3



CROSS SECTION OF WEST PIER



ELEVATION

Fig. 4.

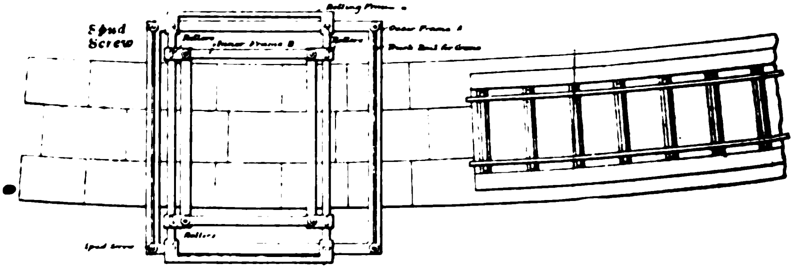


DIAGRAM PLAN

Fig. 5.

Locomotive Stage.

WHITBY HARBOUR EXTENSION WORKS.

arranged so that C could be traversed longitudinally within A, while B could be traversed transversely within C. Frame C was provided with top and bottom rollers, which ran respectively on the upper and under sides of the top longitudinal girders of A. By those means when the spuds of frame A were resting on the ground and those of B lifted, frame B was supported on the upper set of rollers, and could be moved longitudinally through a distance of 9 ft. In a similar manner, when the spuds of frame B were resting on the ground and those of A lifted, frame A could be transversed a like distance of 9 ft. By a repetition of those operations any required amount of travel in a longitudinal direction could be obtained. In order to provide for transverse movement the transverse top girders of the rolling frame formed roller tracks, on which rollers attached to the inner frame travelled in the same way that the rollers of the rolling frame travelled on the outer frame. Motion in two directions was thus provided for, to suit the curvature of the piers.

The outer frames of the stages were 50 ft. by 50 ft. over all in plan and the inner ones 40 ft. by 30 ft., both being 33 ft. high. Each stage was furnished with a 6-ton traversing-crane of the double cantilever type, having a radius of action of 100 ft. longitudinally and 33 ft. transversely. The total weight of each stage, including the crane, was about 130 tons. The stages were constructed by Messrs. Head, Wrightson & Co., of Stockton-on-Tees, and were erected on the beach behind the old West Pier at the point marked X on *Fig.* 1. From thence, when completed, they travelled to their respective places of operation —in the case of the east one a distance of about 3,600 ft.—the speed of travelling being about 300 ft. in 10 hours. Afterwards, when more experience had been gained, this speed was very much increased. *Fig.* 7 shows a heavy sea striking the outer end of the west pier during its construction, and will give some indication of the stresses to which the stages were subjected.

About thirty trial-borings were made on the site of the proposed new works, and those on the site of the west pier showed that for more than half of its length the rock was overlaid by a layer, 4½ ft. thick in places, of sand and gravel, interspersed with large stones which ranged in weight up to about 13 tons. Over the remaining portion the shale was free from sand and gravel, but was strewn with a considerable number of large stones. In addition to those materials there was over a considerable portion of the site of this pier a layer 3 or 4 ft. thick of unsound shale, quite unfit for founding on. In the case of the east pier the shale was quite sound and hard and was overlaid only by some large stones with, at the landward end, a thin layer of sand.

Attempts were made to prepare the foundations by means of a bucket-ladder dredger, and thereafter a sand pump was tried, but both methods were abandoned in favour of grab-dredging and divers, the removal of the unsound shale, which resembled tough boulder-clay, being very troublesome. The rock dips towards the west at an angle of about 5° and the beds are generally about 18 in. to 24 in. thick. The foundations ranged in depth from about 2 ft. to 12 ft. below low-water level, those of the east pier being on an average considerably shallower than those of the west pier, especially towards the landward end. The general method of procedure in preparing the foundations where there

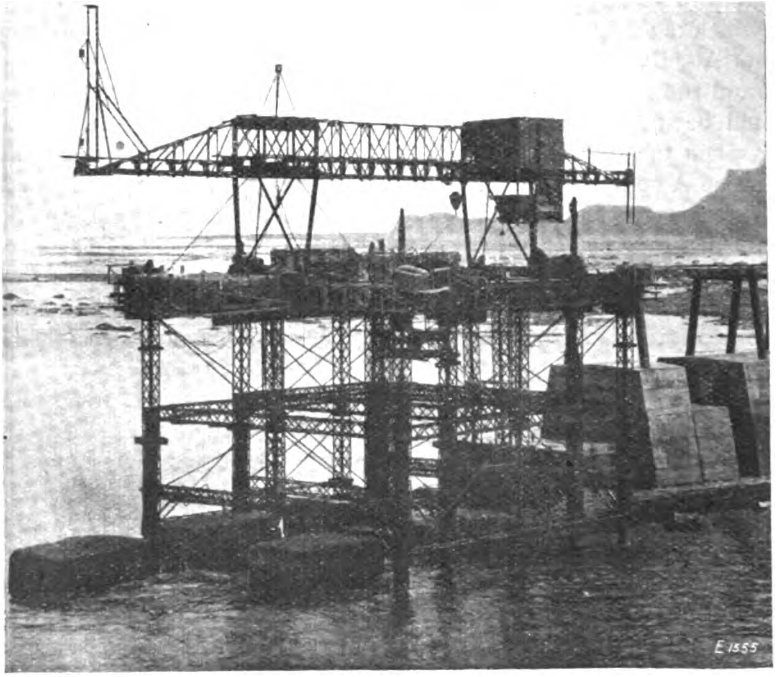


**Fig. 6.** East Pier—Locomotive Stage.

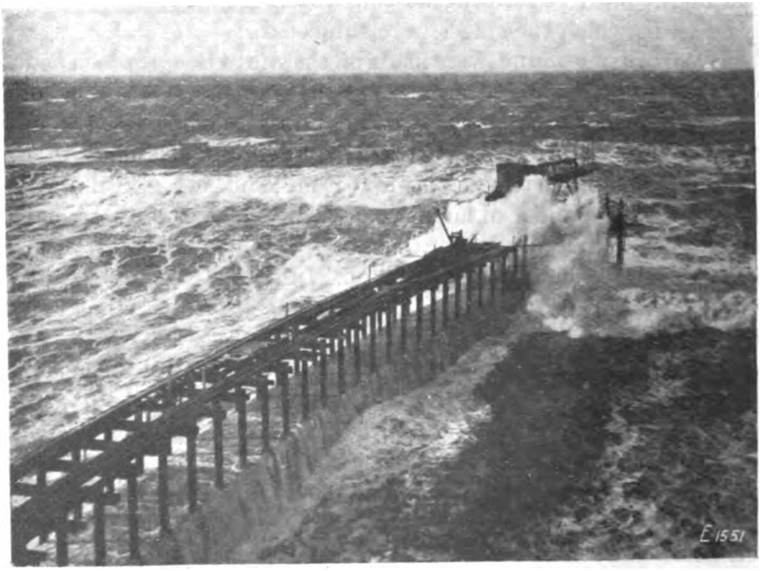


Fig. 7. Wave striking new West Pierhead during construction.

WHITBY HARBOUR EXTENSION WORKS.

was a considerable thickness of sand, stones, etc., was first to clear as much of the material away as would permit the casing for the concrete to be set, and then to complete the excavation within the shelter of the casing, a grab being used where possible, so as to minimise diving work.

The concrete casings for the substructure blocks measured 15 ft. by 10 ft. in plan by 5 ft. high, two or more casings being set one above the other when required by the depth of the foundation. They were made of redwood, 4 in. thick, the planking being horizontal and bolted to 9 in. by 3 in. vertical ledges, each side and end forming a complete panel. The joints between the planks were made tight by two thicknesses of jute canvas fastened to the edges of the planks by tacks. The ledges projected about 12 in. above the upper edges of the casings, and served to keep the upper casings in position after they had been set in place. The top halves of those projections were bevelled inside, so as to facilitate the setting of the upper casings.

The casings were bolted together on the top of the pier, picked up and lowered into position by the crane, and finally fixed and completed by divers. To facilitate the work of stripping off the casings after the concrete had hardened, the tie-rods connecting the sides and ends were slipped into slotted holes in the side panels and kept in place by catches. On slackening the nuts and lifting the catches the bolts could be easily withdrawn. In order to prevent the casings from being displaced, in the event of the sea becoming rough before the concrete could be placed in them, they were heavily weighted with iron. As much of this, in the form of old dredger-links, was bolted to the casing as possible, while still keeping the weight just within the lifting capacity of the crane, and after the casing had been set in position cast-iron weights of about 30 cwts. each, having loops of chain attached to them, were hung over the projecting ends of the ledges. When another casing had to be placed on top of the lower one those weights were lifted off till the upper casing was set and then hung on to it in a similar manner. The surface of the rock was very uneven and the spaces between it and the bottom of the lower casing were closed by nailing to the casing vertical boards about ¾ in. thick. Those boards were bevelled at the lower end, and were driven hard down on the rock so as to make as tight a joint as possible. An apron of jute canvas was then nailed round the foot of the casing, so as to cover the poling boards, and with sufficient width to turn inwards 9 in. or so on the bottom. When the concrete was deposited on this apron it sealed the bottom edges of the casing against the wash of the sea.

The concrete was conveyed from the mixers to the outer end of the pier in small tipping-wagons and there (for under-water work) emptied into a skip, by which it was finally placed in position. The wagons were run from the mixer to the outer end of the old pier by a double-line cable railway, pulled round the curve connecting the old and new piers by an electric winch, and thence pushed by men to the place of deposit. The concrete-depositing skips were of 60 cu. ft. capacity and were eminently satisfactory in use. They very seldom fouled under water and there was no trouble from concrete sticking to them. Two canvas flaps were attached to the top of the skip and were folded over the concrete so as to prevent the sea from washing its surface during the lowering through the water. Each flap was weighted by means of a piece of ¾ in. diameter chain attached to the meeting edge. On account of the superiority of work produced by concreting "in the dry" as compared with depositing the material through water, it was usual to put in the upper 2½ or 3 ft. of the substructure blocks by tide-work. When this was done the concrete was covered, before the tide flowed over it, by a sheet made of two thicknesses of jute canvas and of sufficient size to overlap the edges of the casing. Lengths of 1½ in. by 1 in. timber were then laid on the casing and nailed through the canvas sheet. On the canvas cover were laid panels of ⅝ in. steel plate stiffened with angle bars. Those panels were made up from available scrap material. As they offered very little hold for the sea they were rarely displaced, and concrete so covered was able to withstand a very rough sea. The greater part of the concrete in the superstructure was deposited by means of a shoot, as this enabled it to be more quickly handled than when using a skip—an important consideration in the case of tide-work—the concrete in this case being tipped direct from the wagons into the shoot. In depositing fresh concrete on that which had previously set, the surface of the latter, after having been cleared from loose and defective materials, was, when it bared at low water, covered with a thin layer of dry cement (about ⅛ in. thick) before depositing the concrete, while in the case of under-water surfaces extra cement was put into the first two or three skipfuls of concrete deposited. Special care was taken to ensure that an ample quantity of water was used in mixing all concrete, more particularly for under-water work.

The general method of procedure in constructing the foundation blocks at the west pier was to build out two side walls 10 ft. wide, and afterwards fill in the centre width of 11 ft. The centre bays were generally made 18 to 25 ft. long, as against 14 ft. in the case of the side walls. For advancing the side walls three-sided casings were used. For this purpose, in erecting a casing, one of the ends was replaced temporarily by two timber struts about 10 ft. 3 in. long, which were kept in position by the usual two ⅞-in. diameter tie-rods, placed in this case 12 in. from the end of the casing. The casing was lowered so that the sides at the open end overlapped the previously-deposited block to the extent of 12 in. The nuts of the tie-rods were then slackened, the struts withdrawn, and the nuts again tightened, thus fixing the casing firmly in position, after which the 30-cwt. weights were hung on it. The casings for the centre bays were simple panels, and for fixing them holes were bored in the concrete of the side-walls into which 1½ in. diameter steel pegs were driven, the casings being held against the pegs by hook-bolts. Blocks and tackle were used for holding the casing in position till the hook-bolts were fixed—often a work of considerable difficulty when there was a ground swell in the sea. At the east pier the method was slightly different. Two isolated side-blocks, 15 ft. long, were first built and the hearting space between them then filled, the casings for the latter being fixed by means of steel pegs and hook-bolts as already described. A similar set of blocks was built 10 ft. farther ahead, after which the 10 ft. gap was filled in, and so on. After a suitable length of the concrete substructure had been completed to the height of 3½ ft. above low-water level the locomotive stages were moved ahead to permit of the completion of the superstructure.

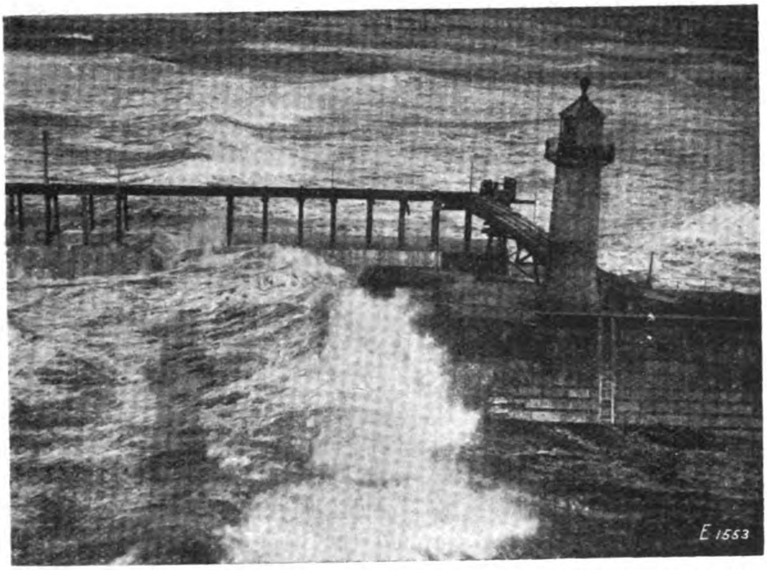


Fig. 8. Wave striking old East Pierhead before the construction of the East Intercepting-Wall.

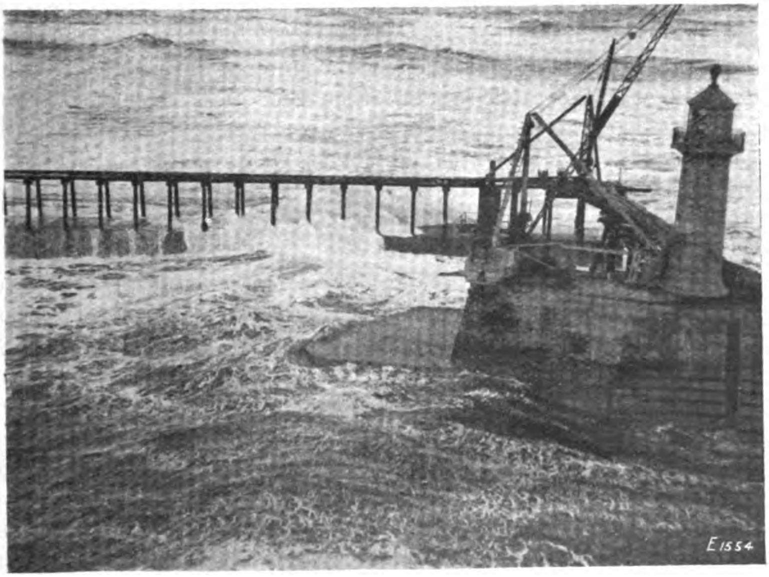


**Fig. 9. East Intercepting-Wall during a strong swell.**

WHITBY HARBOUR EXTENSION WORKS.

The concrete superstructure at both piers was built as a rule in lengths of 11 ft., the height completed in a tide below high-water level being about 4 ft. At high-water level the timber uprights were set and the upper 7½ ft. of concrete was completed at one operation. At the west pier the casings (as in the foundations) were three-sided, while at the east pier the method of "pillar and gap" (as in the foundations) was followed.

The blocks composing the substructure of the new pier heads were connected together by steel ties, each tie being composed of two 80-lb. double-headed railway rails suitably bent.

The frontispiece shows the nearly-completed east pier with a strong swell running along it.

### THE INTERCEPTING-JETTIES.

The intercepting-jetties consist of boundary walls of concrete, filled between with rubble stones grouted with sand, the filling being covered with a concrete decking.

As indicating the efficiency of the wave-traps, already described, *Fig.* 8 shows a wave striking the old east pier head before the construction of the east intercepting-wall, while *Fig.* 9 shows a somewhat similar wave after the construction of the intercepting-wall. *Fig.* 10 shows the west intercepting-wall, and *Fig.* 11 shows a wave passing through the west wave-trap. The difference between the amount of wave motion on opposite sides of the two intercepting-walls is very remarkable. The difference between the wave motion in the upper regions of the harbour during storms, and that which existed before the completion of the new works, is equally striking, vessels being able to lie at the new fish-quay in any kind of weather.

Although heavy seas were frequently encountered during the construction of the works there was very little loss of either concrete or casings. This must be attributed largely to the proportions of the concrete, which caused it to attain rapidly such a strength as to withstand the destructive action of the sea.

The Portland cement used for the works conformed to the British Standard Specification and was of slow-setting quality, the period of complete setting being on an average about 7 hours. It was tested on arrival at the works, the mortar tests being made with the sand used for concrete making, which was obtained from the beach to the west of the harbour. The gravel was obtained from the rivers Tyne and Tweed. It was specified to have all the sand screened from it, and the proportions of large and small material in it were very satisfactory. At each pier there were two ½-yd. Koppel concrete-mixers. The proportions of the concrete were: 1 cement, 2 sand, 3 gravel for under-water work, and 1 cement, 2 sand, 3½ gravel for above-water work. No displacers were used, although their use above water was optional. The gravel and sand were measured in tipping-wagons having a capacity of 15 cu. ft. The gravel was first filled in, the proper level being indicated by a narrow bar riveted to the wagon. The remaining space was then filled with sand and the surface screeded off. The weight of the cement per cubic foot was carefully determined and agreed on, and it was then weighed into sacks, each containing sufficient for one charge of the mixer.

The timber work of the new piers was of pitch pine and, with the exception of

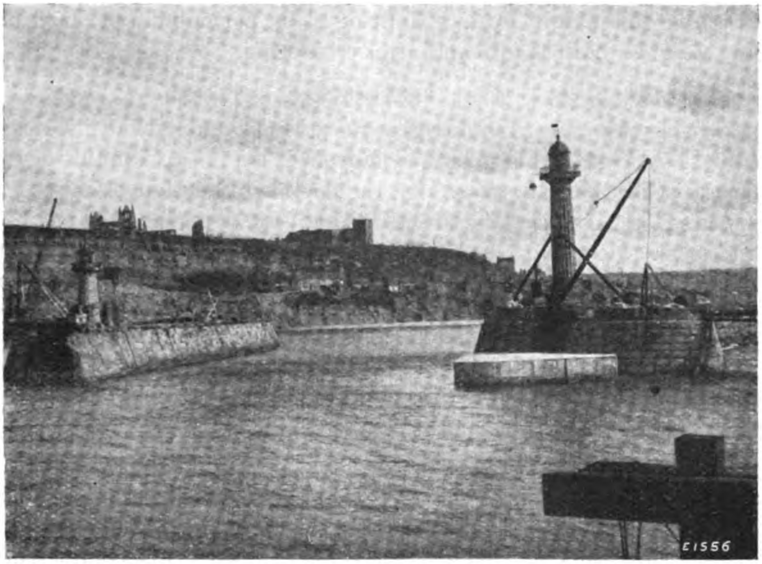


Fig. 10. View showing old Pierheads and West Intercepting-Wall.

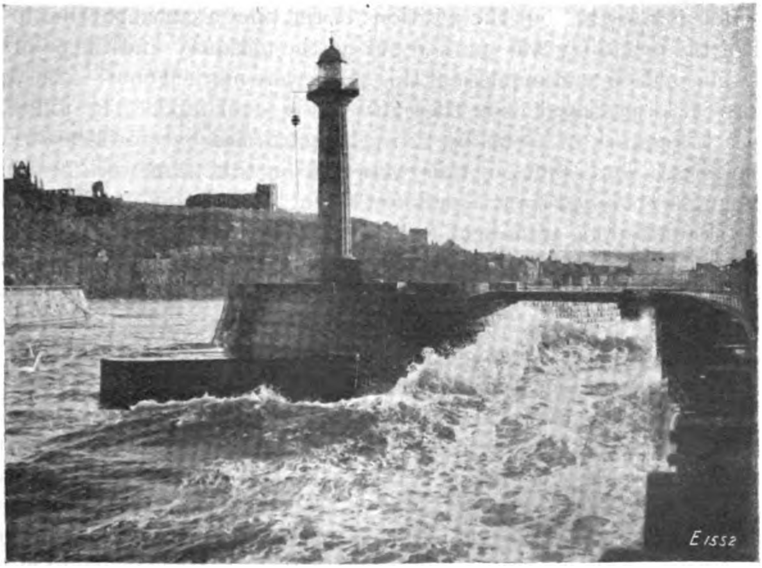


**Fig 11. West Intercepting-Wall during a strong swell.**

WHITBY HARBOUR EXTENSION WORKS.

the deck planking, was creosoted. The creosoted timber was specified to contain not less than 7 lbs. of creosote per cubic foot, and a premium was paid for all the oil injected above this weight up to a limit of 10 lb. per cubic foot, each piece of timber being weighed both before and after creosoting.

### THE FISH-QUAY.

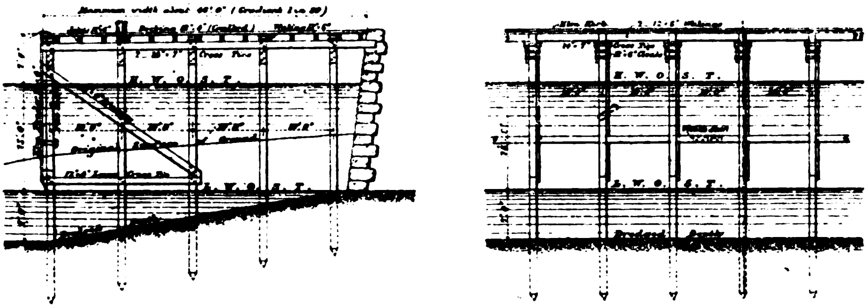
The new fish-quay (*Figs.* 12 and 13) is 700 ft. long, and its width varies, owing to the irregular shape of the old quay. The front is curved to a radius of 1,430 ft. and the deck area is about 19,500 sq. ft., the deck being designed to carry a load of 2½ cwts. per sq. ft. The deck is 7 ft. above high-water level at the front—rising towards the back with a gradient of 1 in 80. The quay is constructed of creosoted pitch-pine, with the exception of the deck planking, which is uncreosoted, and the fenders and coping, which are of Canada rock-elm.

Owing to the irregularities of the strata as disclosed by the borings, a number of the piles were driven as test-piles before the lengths of the remaining ones were decided on. Considerable difficulty was experienced in driving the piles. In a few cases they were withdrawn and obstructing boulders were shattered by charges of blasting gelatine, while for a considerable distance at the north end of the quay, where very tough shale was met with above low-water level, holes were blasted for the front piles, so as to allow them to be driven to a sufficient depth to permit of the dredging alongside the quay being afterwards completed. The piles were of 12 in. by 12 in. scantling, a special type of shoe being used for driving into the shale. The set to which the piles were driven was an average of ¼ in. on each of the final seven blows, using a 43-cwt. steam hammer with a drop of 3 ft. For setting out the positions of the piles a curve parallel to that of the front of the new quay was marked out on the old quay, and the points where the centre-line of each bent of piles cut this curve were marked on it. The positions of the piles were measured from this curve by a steel tape. The piling engine rested on a framework of 12 in. by 12 in. balks carried by crown-beams laid on top of the piles. Three lines of rails were laid on this framework and on these the piling engine travelled transversely to the length of the quay. The framework was easily skidded along from bent to bent by means of crowbars.

The inner ends of the cross-ties were let into recesses cut in the masonry of the old quay-wall. When all the piles had been driven and those cross-ties bolted on the irregularities in the front curve of the quay were smoothed out by means of hydraulic jacks, after which the fronts of the recesses were boarded up and the ends of the ties encased in concrete.

The deck planking was of the same special quality as that used in the roadways of the new piers, the sapwood being restricted to not more than ½ in. measured from any one edge of the planks. The planks were laid close together (those of the pier roadways had spaces of 1 in. between them) and the joints caulked with two threads of oakum and pitched, surface drainage being provided for by boring four 1½ in. diameter holes through the planking behind the coping in each 10 ft. length of the quay. Mooring-bollards 1 ft. 9 in. high are formed at intervals of 50 ft. by piles projecting above the deck, with wych-elm cleats nailed on them. For convenience in landing fish, and for pleasure-boat purposes, three stairs are provided, while in addition to these there are six iron ladders.

Dredging was carried on by means of a bucket-ladder hopper-dredger having a hopper capacity of 220 cu. yd. and capable of lifting about 120 tons per hour. Owing to the small depth of water available at the harbour entrance, the number of hours worked per tide was very restricted. The materials dredged consisted of sand, gravel, clay, freestone and shale, the quantity being about 125,500 cu. yds. measured in place. Part of the shale was brittle and was easily dredged, but a tougher variety was very troublesome. A ledge of sandstone rock of considerable area required to be bored and blasted before the dredger could remove it, and a good deal of blasting was required in breaking up large stones.



ELEVATION

CROSS SECTION.

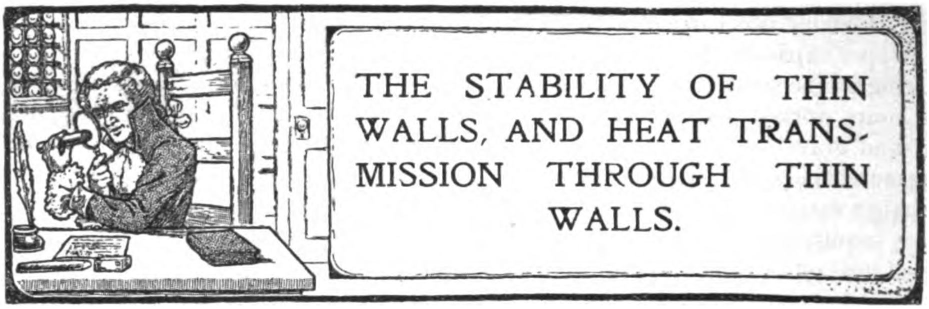
Figs. 12 and 13. New Fish-Quay.

Whitby Harbour Extension Works.

Electricity was used throughout the works, both for power and light, and was obtained from the power station of the Whitby Urban District Council. The motor houses, cement stores, and concrete mixers were erected at the landward ends of the old piers. The Contractors were very much hampered by lack of storage room for their plant and materials, the cliff at the root of the west pier rising rapidly to 100 ft. above high-water level, and that at the east pier still more abruptly to 200 ft., while they were only allowed the use of half of the width of the old west pier, so as not to interfere with its use as a promenade. Owing to the conformation of the ground all the cement, gravel, etc., for the east pier works had to be taken from the west to the east side of the harbour by barges.

The works were designed by Messrs. J. Watt Sandeman & Son, civil engineers, Newcastle-on-Tyne, and were carried out under their direction, the author being resident engineer, and having as his assistant, Mr. A. B. Strachan, Assoc.M.Inst.C.E. The execution of the works throughout is a credit to the contractors, Messrs. W. Hill & Co., of Westminster, whose agents were, first, Mr. R. A. Piercy, and thereafter Mr. F. S. Habell, A.M.I.Mech.E.

*Figs.* 1, 2, 3, 4, 5, 12, and 13 have been reproduced from the Minutes of the Institution of Civil Engineers by the kind permission of the Council. The remainder of the illustrations are from photographs by Mr. F. R. Sutcliffe, Whitby.



# THE STABILITY OF THIN WALLS, AND HEAT TRANSMISSION THROUGH THIN WALLS.

*Below we publish abstracts from an interesting article which recently appeared in "Housing."—ED.*

THE subjoined sections of the Report of the Building Materials Research Committee under the Department of Scientific and Industrial Research are published in advance of the body of the Report, with the sanction of the Department. These sections, comprising the results of researches on (1) the stability of thin walls, and (2) heat transmission through thin walls, are based on experimental work carried out under the direction of the Committee.

## (1) STABILITY OF THIN WALLS.

Tests were made on several commonly used materials, and each material was loaded to destruction in three ways: (1) small cubes generally 6 or 9 in. square were crushed in order to ascertain the strength of the material when not used as a thin structure; (2) columns or pillars 14 in. wide from 2⅝ in. to 4½ in. thick, and 8 ft. 6 in. high. These narrow, thin walls or pillars were crushed, and their relative strengths compared with the cubes ascertained; (3) short lengths of wall 3 ft. 6 in. wide from 2⅝ in. to 4½ in. thick and 8 ft. 6 in. high. These were subjected to a vertical load of about one ton per lineal foot of wall, and, while thus loaded, a horizontal pull was applied to the wall at the middle of its height until failure took place.

As the investigation was somewhat tentative, a part only was undertaken in the first place, and a second series of tests was begun after the first results were available. The results are given in the accompanying table.

Considered as a whole the results obtained are remarkably consistent, more so than is usually the case in tests of full-sized specimens. The principal facts brought out are the high relative resistance to crushing shown by the slender walls or pillars, and the weakness of the lime mortar compared with Portland cement when tested in this way. With the exception of the wall built with lime mortar, the crushing strength of the walls varies from 67 to 83 per cent. of the strength of the same material crushed in cubes. The lime mortar only showed 32 per cent. *The high percentage strength is to some extent due to the care exercised in centring the column under test.* It is, however, clear that strengths approaching these can be developed in practice, provided care is exercised in the bedding of the joists so that the load acts as nearly as possible through the centre of the wall. It is also necessary that the wall should be absolutely vertical.

Reference to items 5 and 6 of the above Table of Results shows that the walls built with Fletton bricks on edge in cement (2⅝ in. thick) resisted a much higher crushing load and horizontal pull than those built with the same bricks laid flat in lime mortar (4½ in. thick).

The coke breeze specimens showed low resistance to crushing, but a comparison of the strength of the cubes with that of the walls shows that, in spite of the low strength of the material, the percentage of strength of the wall is high as compared, for example, with that shown by the wall composed of Fletton bricks. Against the horizontal pull they gave better results than would be expected. All the concrete and breeze blocks show a high resistance to the transverse loads as compared with walls formed from smaller units such as bricks.

RESULTS OF EXPERIMENTS ON STRENGTH OF THIN WALLS.

| | Description. | Crushing strength of cube. | Age of cube when tested | Crushing strength of wall 14 in. wide by 8 ft. 6 in. high. | Age of wall when tested | Horizontal pull to break wall 3 in. to 6 in. × 8 ft. 6 in. high under vertical load of 1 ton per ft. run. | Age of wall when tested under horizontal pull. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | lbs. per sq. in. | days. | lbs. per sq. in. | days. | lbs. | days. | |
| 1 | Stock bricks 3 to 1 cement mortar wall 4½ in. thick (9×9×9) .. .. .. | 770 | 26 | 638 | 24 | 895 | 34 | In this specimen a vertical load of two tons per ft. run applied in connection with horizontal pull test. |
| 2 | Ditto, 6 to 1 cement mortar.. | 720 | 26 | 562 | 23 | 791 | 41 | |
| 3 | Fletton bricks 3 to 1 cement mortar wall 4½ in. thick .. | 1,530 | 26 | 1,040 | 24 | 781 | 39 | |
| 4 | Ditto, 6 to 1 cement mortar wall 4½ in. thick .. .. | 1,250 | 26 | 930 | 23 | 705 | 36 | |
| 5 | Ditto, 3 to 1 lime mortar wall 4½ in thick .. .. .. | 1,050 | 22 | 330 | 24 | 375 | 27 | |
| 6 | Ditto, on edge, 3 to 1 cement mortar wall 2⅝ in. thick .. | 1,470 | 29 | 1,040 | 23 | 553 | 44 | |
| 7 | Concrete, 1 : 2 : 4 wall 4½ in. thick cast in one piece .. | 1,480<br>2 250 | 22<br>42 | 1,230 | 26 | 1,262 | 27 | |
| 8 | Concrete blocks, 1 : 2 : 4, set in 3 to 1 cement mortar wall 4½ in. thick 14 in. × 9 in. × 4½ in. .. .. .. | 1,480<br>2,250 | 22<br>42 | 1,510 | 22 | 1,253 | 25 | |
| 9 | Concrete blocks (Winget, 4 : 2 : 1) wall 4½ in. thick (block 6 in. × 6 in. × 4½ in.) | 743† | 120 | 580 | 24 | 962 | 44 | |
| 10 | Concrete blocks, 4 : 2 : 1 (wet process) wall 3 in. thick (block 6 in. × 6 in. × 6 in. : 6 in. × 6 in. × 3 in.) .. .. | 1,630†<br>1,240† | 29<br>29 | 1,130 | 24 | 700 | 32 | |
| 11 | Coke breeze blocks, wall 3 in. thick (6 in. × 6 in. × 3 in.) .. | 236† | unknown | 170 | 22 | 467 (slab) | 41 | |
| 12 | Coke breeze blocks wall 4 in. thick (6 in. × 6 in. × 4 in.) .. | 243† | Do. | 173 | 22 | 658 (slab) | 41 | |

† These specimens were cut from a larger block as true as possible but not faced, and no doubt were really stronger than the tests indicate.

It appears from the tests that walls as thin as 2⅝ in. can safely be used for partitions in cottage building, even when supporting the joists.

### (2) HEAT TRANSMISSION THROUGH THIN WALLS.

Tests of the heat loss through various types of thick walls have been made from time to time; of these special attention may be directed to the work carried out by Mr. A. H. Barker, Wh.S., B.A., B.Sc., Professor W. M. Thornton, D.Sc., D.Eng. of Armstrong College, and at the National Physical Laboratory. A considerable amount of work on this subject has also been done abroad, particularly in America and in Germany. The Committee thought, however, that further tests were desirable in reference to thin walls and walls of new types of construction. They therefore decided to ask Mr. Barker to undertake for them a research into the heat transmission through some seven different types of wall. . . . It may be sufficient to remark here that the tests were carried out in a laboratory under carefully-considered conditions, namely, in still air with walls consistently dry. The results obtained are summarised below.

When heat is passing from a region of comparatively high temperature, through a partition of some kind, to a region of low temperature the heat transmitted can be said broadly to depend on—

(1) The construction and material of the wall;
(2) The character of the surface of the wall;
(3) The area of wall;
(4) The temperature difference between the regions of high and low temperature.

The actual heat transmitted in British thermal units in still air will then, for any particular case, be given by the formula :—

$$H=K\,(t_1-t_2)\,A$$

where :

$H$ = British thermal units transmitted per unit time.
$t_1$ = Higher temperature in degrees Fahrenheit.
$t_2$ = Lower temperature in degrees Fahrenheit.
$A$ = Area of the wall in square feet.
$K$ = A constant, depending upon construction and material of the wall and condition of the surface.

It will be seen, then, that the constant $K$ (sometimes termed the co-efficient of transmission) will be a measure of the efficiency of the wall as a heat-insulating structure, representing the over-all value of the transmission in British thermal units per square foot per hour per degree difference of temperature on the two sides of the wall.

Values of this constant $K$ for the walls tested by Mr. Barker are given below :—

| *Type of Wall.* | *Value of K.* |
|---|---|
| 9 in. plain unplastered brick wall (London Stock) .. | 0·43 |
| 4½ ,, plain brick wall unplastered .. .. .. .. .. | 0·57 |
| 4½ ,, double brick wall 3 in. cavity (without ventilation) | 0·33 |
| 4½ ,, double brick wall 3 in. cavity (ventilated top and bottom) .. .. .. .. .. .. | 0·42 |
| 4½ ,, rough ballast concrete 6 to 1 .. .. .. .. | 0·61 |
| 4½ ,, rough breeze concrete .. .. .. .. .. | 0·55 |
| 6 ,, rough ballast concrete .. .. .. .. .. | 0·57 |
| 9 ,, concrete blocks with cavity in each block .. .. | 0·52 |
| 4 ,, hollow brick tile .. .. .. .. .. | 0·44 |
| 4 ,, ballast concrete wall outside 2 in. cavity and 4 in. coke breeze concrete inside (without ventilation) .. | 0·30 |
| 4 ,, ballast concrete wall outside 2 in. cavity and 4 in. coke breeze concrete inside (ventilated top and bottom) .. .. .. .. .. .. | 0·35 |

Thus, of the walls tested by Mr. Barker, the 4½ in. rough ballast concrete wall offers the least resistance, while the 10 in. concrete cavity unventilated wall with the inner partition of coke breeze offers the greatest resistance to the flow of heat. The latter type of wall doubtless partly owes its efficiency as a heat insulator to the porous nature of the breeze, as it is, of course, a well-known fact that good insulators, such as cork, slag wool or wood, owe their insulating properties to the large number of small air spaces contained within their mass.

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# CONCRETE COTTAGE CONSTRUCTION.

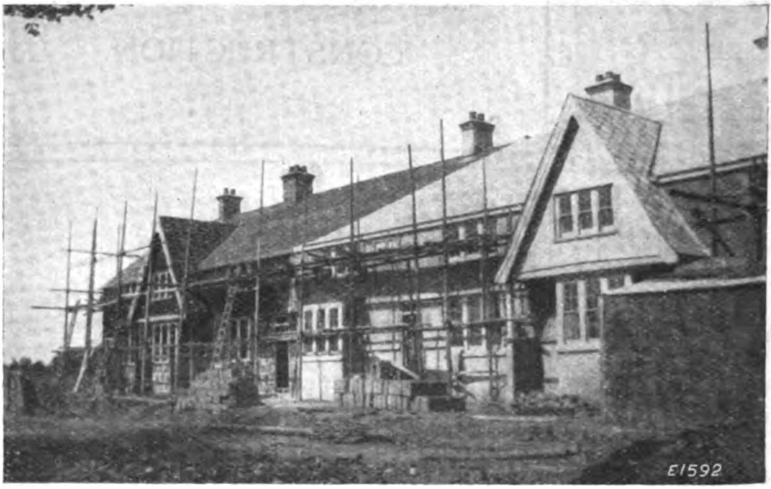
## BOGNOR HUTTING SCHEME.

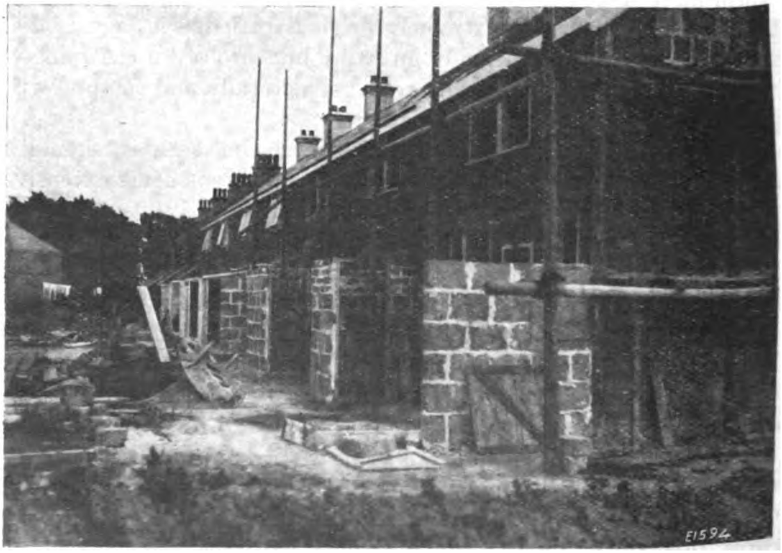
An extremely interesting scheme for the conversion of Army huts is nearing completion at Bognor. Most readers are familiar with the ordinary Army huts —many, probably, having had, perforce, to make their home in them on more than one occasion during the last six years—and with the usual method of converting them into temporary dwellings. This method generally consists in suitably dividing them into rooms and building a fireplace and installing a sink and sanitary fittings, and perhaps effecting certain minor alterations and improvements to render them more weatherproof and more suitable as dwellings.

At Bognor, however, an extremely original plan has been adopted which has resulted in the transformation of an Army hut into seven charming working-class dwellings, which are thoroughly sound structurally and comply with all the latest ideas of comfort and accommodation.

It may be wondered why this matter, interesting as it is, should be dealt with in a concrete journal. The reason is that concrete is being extensively used in the work of conversion; indeed, it is probable that had this material not been available, the work would not have taken place; it is certain that but for its use the work could not possibly have been executed so cheaply or so expeditiously.

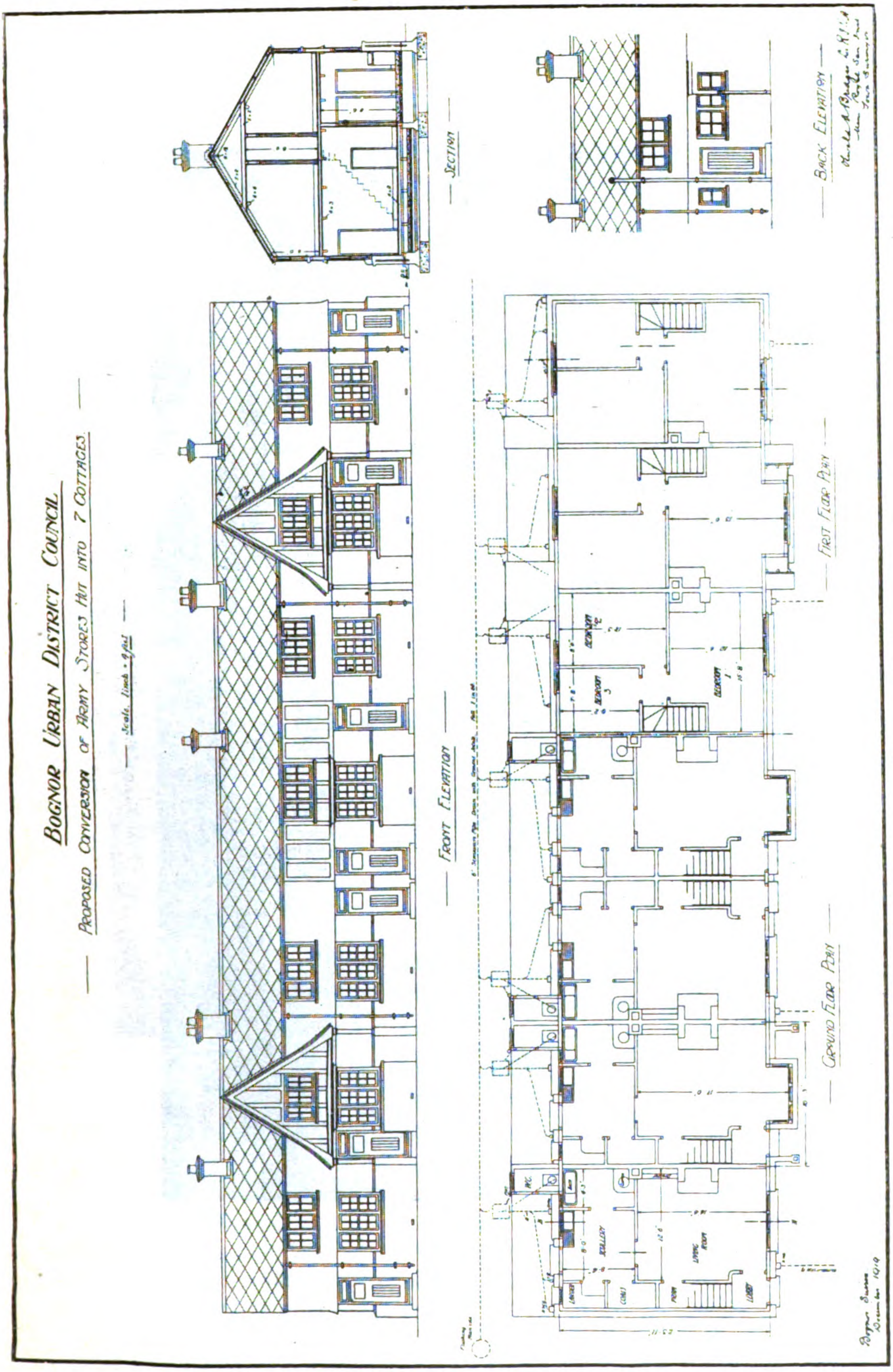
The original idea of the Borough Council in deciding to purchase the hut was to convert it into two or three bungalow dwellings, to house certain extremely necessitous cases—persons whose homes had been condemned as being insanitary and unfit for human habitation. The hut was of the kind known as a Harrod sectional Army Stores hut, and measured 108 ft. by 20 ft. 10 in., and its average height was 13 ft. 10 in. This work was to be carried out under the supervision of the borough engineer and surveyor, Mr. Oswald A. Bridges, who, when measuring up the hut and considering how best to effect the conversion, arrived at the conclusion that for a comparatively slight additional expense an altogether superior kind of dwelling might be obtained, and one of a far more permanent nature than that originally contemplated. The fact that led to this idea was the height of the hut—nearly 14 ft.—which would form a room both costly to heat and difficult to ventilate, and one, furthermore, which would be neither cheerful nor comfortable. In view of these facts, Mr. Bridges suggested to his council that the building should be raised 5 ft. on concrete walls, that the length and width should be somewhat increased, and that another floor should be constructed. In this way seven two-storey dwellings, with properly proportioned rooms, could be obtained.



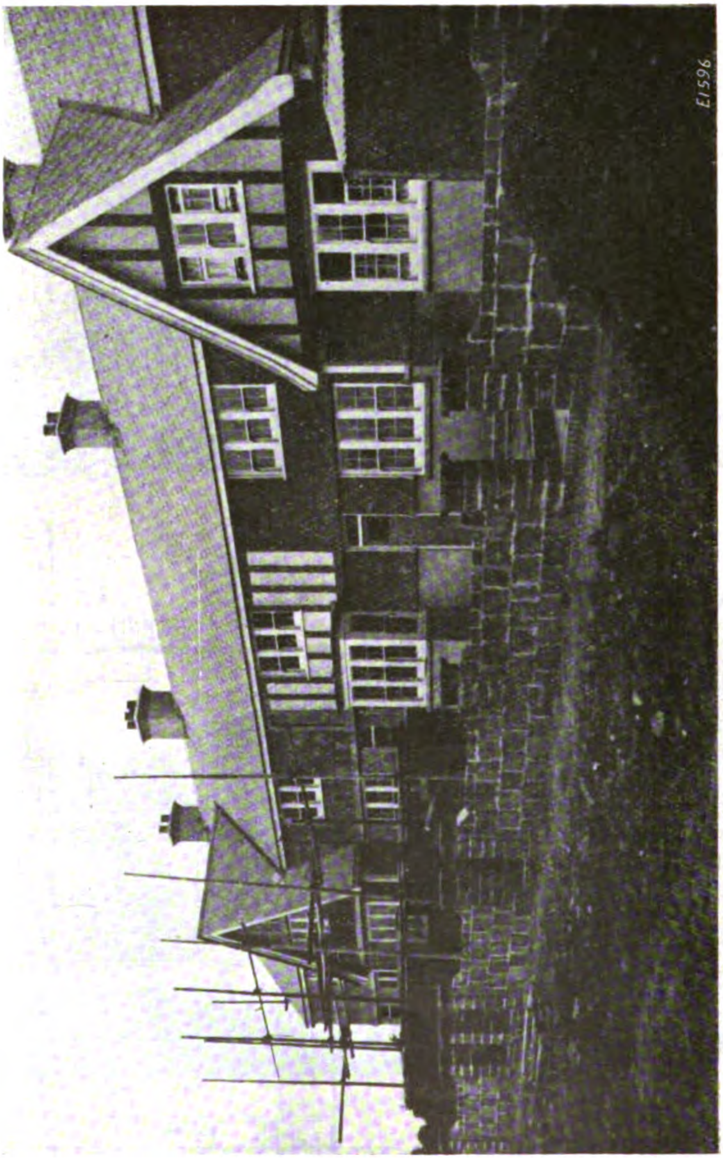


BOGNOR HUTTING SCHEME.

It will be seen by examining the plan that the cottages are of the A or non-parlour type, each containing a living room, equal to the Ministry of Health's standard of 180 ft. super (those with the projecting bays considerably exceeding this figure), a scullery, larder, large bath and wash-house, a w.c.; and, on the first floor, three bedrooms.



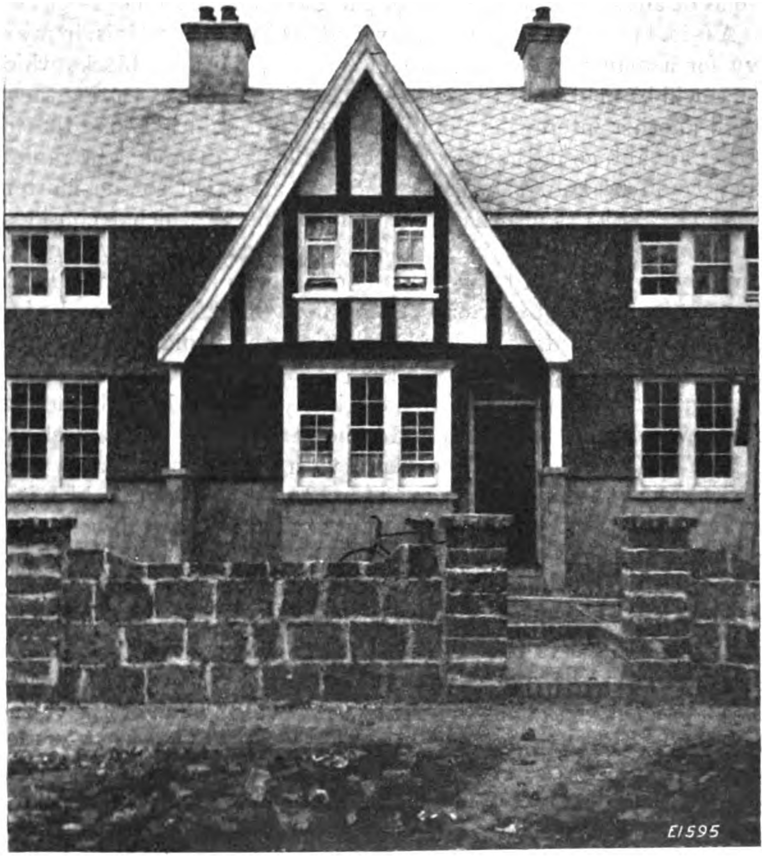
Plans and Elevations.
The Bognor Hutting Scheme.



General View of Finished Cottages.

The Bognor Hutting Scheme.

The whole hut is raised upon hollow walls, 5 ft. in height, made of concrete blocks, forming a plinth slightly above the ground floor sill level. The party walls are constructed of solid concrete, 6 in. thick, carried up to the apex of the roof, and the partition walls, on the ground floor, are 4 in. in thickness. The various advantages and disadvantages of the wet and dry systems of manufacturing concrete blocks have often been discussed in this journal, and the general conclusions reached are that wet mixing is, on the whole, a sounder method, allowing the block to harden and season more slowly so that the process of combination takes place more naturally, thus minimising risk of mere surface hardening, whereas the dry method is far more expeditious and requires a fewer number of moulds, thus its plant is more portable. The method adopted at Bognor was the wet method, and the blocks were made in moulds 18 in. by 12 in.



View of Finished Cottage.
THE BOGNOR HUTTING SCHEME.

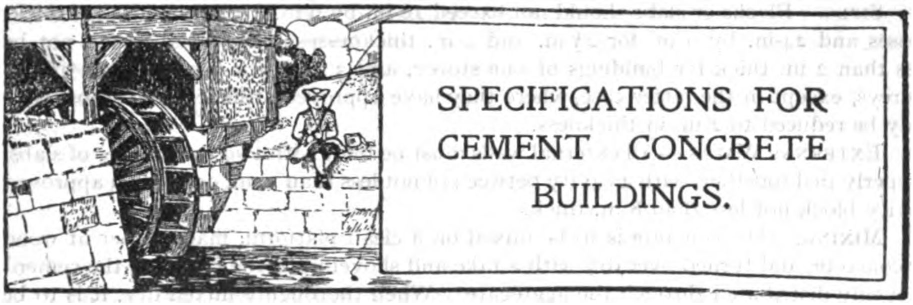
The aggregate was clinker from the refuse destructor and the proportion 6 to 1. All the walls were stiffened with cement rendering and Pudlo was mixed with the external rendering. All the rooms are plastered internally. Although the blocks were used unusually quickly after manufacture, and have been subjected to considerable crushing strain, there has not been a single case of crumbling or collapse, which shows that great care must have been taken in the process of mixing and in ensuring that exactly the correct amount of moisture was employed.

Concerning the size of the blocks, Mr. Bridges states that, " In my opinion, there is one disadvantage in the size of the blocks which I used—that is, their weight. A 6-in. block of 12 in. by 18 in. weighs 84 lb. Now this is, in my opinion, too heavy for a man to lay, and, in consequence, the next blocks which I am going to use will be made half that size—viz., 12 in. by 9 in. During the progress of the work another interesting point was observed, and it is one that discloses yet a further advantage in the use of concrete blocks—namely, the rapidity with which they could be laid. Mr. Bridges draws attention to the matter in the following way : " Blocks also have another advantage which I consider a very great one—viz., the rapidity with which they are laid. However cunning a bricklayer may be he cannot tell how many of them to lay per day. He has been taught by past experience to lay only 300 ordinary bricks, but when laying blocks the work rises so rapidly that he has hardly time to calculate what he is doing." Surely this is a factor of great importance.

With regard to the hut itself, this originally consisted of weather-boarding, and it has now been counter-lathed and lathed and then " pebble-dashed." The roof has been boarded, felted and covered with Fibrocement slates. New sash window frames have been installed on the front of the building, which is exposed to the severe south-west gales. The illustrations show the work in various stages of completion, and it must be conceded that to recognise an Army hut in this delightful group of houses would be a difficult feat. If any criticism of the elevation is to be offered it is that the scantling of the uprights supporting the overhanging gable appears to be far too slight and out of proportion with the massive barge-boards. A more successful treatment would have been by means of a pair of brackets springing from the wall, which is a perfectly traditional method of handling such a problem.

The job throughout is proving to be an example of economy. During the war the use of by-products—waste material thrown off, as it were, in the process of manufacture or of the daily routine of life was greatly developed. The bulk of the material used in the construction of these buildings is in the nature of waste. The hut itself was surplus war material and the aggregate of the concrete, refuse destructor clinker, was often, before the war, looked upon as an encumbrance with which local authorities found difficulty in disposing.

It should be added that the scheme is being carried out entirely departmentally by the Bognor Urban District Council, the estimated cost of conversion was the exceptionally low figure of £413 per house, and there appears very little likelihood that this figure will be much exceeded. Mr. Bridges carried his idea in the face of much opposition, official and otherwise, and both he and his council are to be congratulated upon the novelty and success of the enterprise.



# SPECIFICATIONS FOR CEMENT CONCRETE BUILDINGS.

We give below the standard specifications for cement concrete building which have been approved by the Ministry of Health. Houses conforming with these specifications will rank for a subsidy under Section 7 or Section 19 of the Housing, Town-Planning, etc., Act, 1919, or for a grant under Section 1 of the Housing (Additional Powers) Act, 1919, whether or not the form of construction is one which has been officially approved. Any questions as to the use of clinker or the interpretation of this specification may be referred to the Regional Housing Commissioner. Any proposed scheme which does not conform with these specifications or has not already been approved by the Ministry must be submitted to the Ministry for approval.

The specifications may be obtained from H.M. Stationery Office, price 1d. net.

### SLABS AND BLOCKS.

**Cement.**—The cement is to be Portland, of slow-setting quality, and is to comply with the requirements of the current Specification of the British Engineering Standards Committee.

**Ballast Aggregate.**—The aggregates for blocks and slabs, other than clinker, are to be granite, hard stone, or gravel broken to various graded sizes and with sufficient clean sharp sand to fill up interstices. The aggregate for concrete 3 in. thick and over shall pass a ¾ in. square mesh ; for concrete 2 in. to 3 in. thick shall pass a ½ in. square mesh ; and for concrete less than 2 in. thick shall pass a ¼ in. square mesh.

**Composition.**—The concrete for slabs or blocks of various thicknesses is to be composed by measure as follows :—3 in. thick and over, 6 of aggregate, including sand, to 1 of cement ; under 3 in., 4 to 1 ; cavity blocks with walls less than 3 in. thick, 4 to 1.

**Frogs.**—Blocks of ballast concrete may be made with frogs, the minimum thickness in a 4-in. block being 2½ in., and in a 3-in. block 2 in.

**Clinker Aggregate.**—The clinker must be dense, vitreous, free from organic and combustible matter, well washed and screened to various sizes and mixed with a proportion of sand not less in bulk than 5 per cent. and not more than 10 per cent. Coke breeze will not be allowed. The clinker for concrete 2 in. thick and over shall pass a ½-in. square mesh. The clinker for concrete less than 2 in. thick shall pass a ¼-in. square mesh.

**Composition of Clinker Concrete.**—The concrete shall be composed by measure as follows :—3 in. thick and over, 6 of clinker and sand to 1 of cement ; under 3 in. thick, 4 to 1.

**Waterproof Face.**—Slabs or cavity blocks made of clinker concrete if used for external work shall be cast weatherproof with a waterproofing composition in the case of slabs for the full thickness, and in the case of cavity blocks for the full thickness of the outer face ; or if not waterproofed the external surface of wall shall be finished with a coat of cement rough cast not less than ¼ in. thick.

SIZES.—Blocks or slabs should not exceed 18 in. by 9 in. for 4-in. and 3-in. thicknesses and 24-in. by 9 in. for 2½-in. and 2-in. thicknesses. Plain slabs shall not be less than 2 in. thick for buildings of one storey, and 3 in. thick for buildings of two storeys, except in the latter case, where they have approved stiffeners and webs, they may be reduced to 2 in. in thickness.

EXTERNAL WALLS.—All external walls must be built with two thicknesses of slabs, properly tied together, with a cavity between of not less than 2 in., or with an approved cavity block not less than 8 in. thick.

MIXING.—The concrete is to be mixed on a clean platform, made either of wood or concrete, and turned over dry with a rake and shovel until the colour of the cement is evenly distributed through the aggregate. When thoroughly mixed dry, it is to be again turned over with a due proportion of water applied through a rose to work it to a sufficiently wet consistency, so that if a handful is taken from the heap and pressed, it will retain its shape when the pressure is removed. Not more than 20 per cent. of water by measure shall be used in mixing clinker concrete. A mechanical mixer may be employed if no more concrete is made at one time than is required for immediate use. No concrete, in which the initial set of the cement has taken place shall be used.

AGE.—No blocks to be used for building until they have been properly matured.

NOTE.—All blocks to be made of their full thickness in one operation.

### CONCRETE WALLS BUILT *in situ*.

CEMENT.—The cement is to be Portland, of slow-setting quality, and is to comply with the requirements of the current Specification of the British Engineering Standards Committee.

BALLAST AGGREGATE.—The ballast is to be granite, hard stone or gravel, broken to various graded sizes, the largest to pass a 1-in. square mesh and sufficient clean sharp sand, free from salt, is to be added to fill the interstices.

CLINKER AGGREGATE.—The clinker must be dense, vitreous, free from organic and combustible matter and crushed to pass a ½-in. square mesh. It must be well washed and screened before use, and mixed with a proportion of clean, sharp sand, not less in bulk than 5 per cent. and not more than 10 per cent. Coke breeze will not be allowed.

REINFORCEMENT.—Steel cannot be accepted as a reinforcement in concrete made with clinker.

COMPOSITION.—The concrete is to be composed by measure of not more than six parts of aggregate including sand to one part of cement.

MIXING.—The concrete is to be mixed on a clean platform made either of wood or concrete, and turned over dry with a rake and shovel until the colour of the cement is evenly distributed through the aggregate. When thoroughly mixed dry it is to be again turned over with a due proportion of water applied through a rose to work it to a sufficiently wet consistency, so that if a handful is taken from the heap and pressed, it will retain its shape when the pressure is removed. Not more than 20 per cent. of water by measure shall be used in mixing clinker concrete. A mechanical mixer may be employed if no more concrete is made at one time than is required for immediate use. No concrete in which the initial set of the cement has taken place shall be used for building walls.

THICKNESS OF SOLID WALLS.*—External and party walls of the same composition of concrete throughout shall not be less than 8 in. thick, and internal partition walls not less than 3 in. thick. If the external wall is built partly of ballast concrete and partly of clinker concrete, the inner part of clinker concrete shall not be less than 2 in. thick and the outer part of ballast concrete not less than 4 in. thick, but the total thickness of the wall shall not be less than 8 in. Where the wall is encased between properly prepared and compressed sheets of asbestos not less than ½ in. thick, or other approved material, the thickness of the wall may be reduced to 6 in.; but a projecting corbel course of sufficient strength must be provided to carry the wood joists, or other forms of floor construction, for the upper floor. Where the wall is provided with a continuous efficient vertical damp course in the centre of the wall the thickness may be reduced to 6 in., but the two halves of the wall must be tied together with suitable wall ties every 18 in. in height, the ties to be spaced not farther apart horizontally than 18 in.

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* This is to be interpreted that concrete walls, where composed of two different materials, must, when the wall is completed, form one solid homogeneous construction. Any temporary slip should be drawn immediately the concrete is put into position, and the concrete on both sides is to be rammed so as to get proper amalgamation of the two parts of the wall.

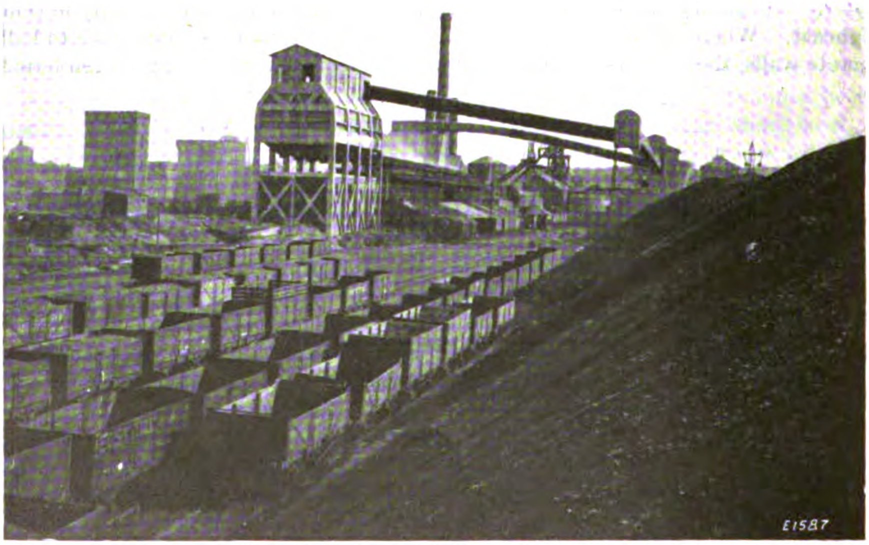
Cavity Walls.—The walls may be constructed with two thicknesses of concrete not less than 3 in. thick and a continuous cavity of not less than 2 in. wide with suitable concrete or galvanised iron wall ties every 18 in. in height and not further apart horizontally than 24 in.

Building of Walls.—The concrete should be placed between the forms or shutterings in layers of not more than 18 in. high at a time, carried evenly round the building in horizontal layers, and is to be thoroughly well rammed. No raking or butt joints can be allowed. Before the next layer is placed, a thick grout of three parts of sand to one part of cement is to be poured over the layer previously rammed. The forms or shutterings are to be kept clean, and are to be removed before the concrete has hardened, in order that the surfaces may be scored for external rendering and internal plastering.

Finishing.—All concrete walls shall be finished internally with an absorbent plaster. All clinker concrete walls shall be rendered and finished externally in cement roughcast. Where the forms or shuttering permit of a smooth external face to ballast concrete walls, these can be finished in durable distemper without cement rendering.

# A NEW 1,000 TON ELEVATED COAL BUNKER.

WE are able to reproduce herewith some interesting photographs and particulars concerning a large elevated coal bunker which was recently completed for the Wombwell Main Colliery Company in Yorkshire. The capacity of the bunker amounts to 1,000 tons of small coal, which is to be used for the supply of an adjoining range of coke ovens



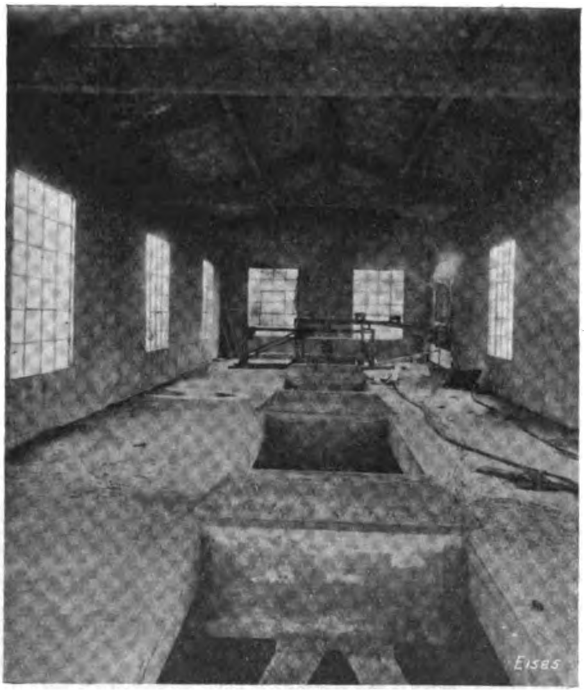
GENERAL VIEW OF BUNKERS AND COKE OVENS.

Messrs. Edmond Coignet, Ltd., were appointed by the company to act as consulting engineers and for the preparation of the complete working drawings for the reinforced concrete, the work being executed by Messrs. Smith Bros. (Burnley), Ltd.

The work was started in the summer of 1918, during the period of hostilities. It was necessary for the owners, therefore, to obtain the sanction of the Ministry of Munitions before proceeding with the construction. In spite of the considerable difficulties in obtaining suitable materials and labour, the contractors were able to proceed with the work which was eventually completed about nine months ago.

The work is composed of a loading platform at a level of about 31 ft. from the railway level. This platform has an area of 73 ft. by 36 ft. 6 in., and was calculated strong enough to support three lines of trucks.

As indicated in the illustrations, the portion of the pillars underneath the platform was strongly braced in both directions, which was considered a necessary precaution on account of the considerable height of the work and the fact that it is very much exposed to wind pressure.



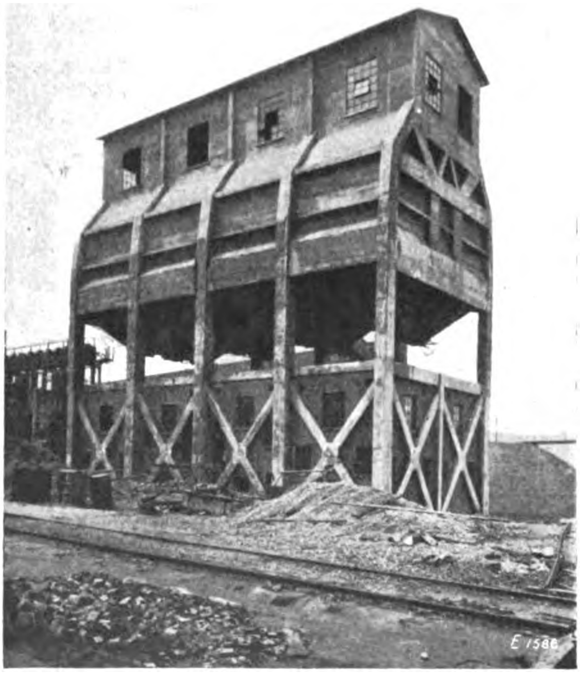
INTERIOR OF CONVEYOR HOUSE.

The body of the bunker is composed of four compartments with three hopper openings at the bottom of each compartment, for the purpose of discharging the coal into the trucks. The loading platform was constructed at the same level as the top of the adjoining coke ovens, so that the trucks being filled they can conveniently be discharged into the ovens.

A clearance of about 6 ft. 6 in. was left between the mouths of the hoppers and the top of the loading platform. The whole of the underside of the loading platform has been surrounded by brick walls with windows and is used as a workshop.

It was found that on account of the difficulty which there would have been in accommodating very deep beams to take the weight of the bunker across a span of 33 ft. 6 in. in the clear, it was necessary to suspend the hoppers by means of vertical ties to reinforced concrete truss girders, constructed in the upper part of the bunker. These truss girders are also made use of for the purpose of supporting a conveyor house which is entirely in reinforced concrete, including the roof.

The general dimensions of the body of the bunker measured 60 ft. in length, by an internal width of 33 ft. 6 in., and a total height of 32 ft., measured from the openings to the top of the truss. As the total height of the work is no less than approximately 100 ft., the supporting pillars required to be designed and constructed in a very strong manner and capable of resisting a certain amount of bending.



ELEVATION OF BUNKERS.

The outside pillars were made of a rectangular section with scantlings of 30 in. by 26 in. These pillars were supported by reinforced concrete continuous foundations, the latter being calculated to spread the load on to the ground at the rate of about 2 tons per square foot. Owing to inconsistent ground it was necessary to construct the foundations towards the rail level several feet lower than originally anticipated.

The whole of the reinforcement was composed of round bars of mild steel arranged in accordance with the Coignet System of reinforced concrete construction. The mixture of concrete throughout the work was 1 of cement, 2 of sand, and 4 of gravel. The inside and the outside of the bunker was made smooth and brushed over with cement wash.

The coal is brought into the top of the bunker by means of a special conveyor belt of considerable length. The coal from this belt is discharged on to another belt mechanically operated from the conveyor house, and the coal is distributed by an automatic arrangement in each of the bins in turn through suitable openings left in the reinforced concrete floor.

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## MEMORANDUM.

**Effect of Storage of Cement.**—The Structural Materials Research Laboratory, Lewis Institute, Chicago, has just issued a report on some tests carried out to ascertain the effect of storage of cement. The Report is by Mr. Duff A. Abrams, Professor in Charge of the Laboratory. The following is a summary of the tests, with the principal conclusions arrived at:

Tests were made on three different lots of Portland cement, which had been in storage for periods up to two years. The cements were stored (A) in the laboratory; (B) in the basement of the building; and (C) in a shed in the yard. In general the cement was stored in lots of 800 to 1,200 pounds, in standard cloth sacks; in one group of tests two brands of paper sacks were also used. In another group the cloth sack containers were covered with thin layers of (1) Portland cement and (2) hydrated lime. Tests were made at ages of 7 and 28 days, 3 months, 1 and 2 years, on samples taken immediately upon receipt from the dealers' warehouses and after storage for 3 and 6 months, 1 and 2 years.

This report includes compression tests of about 1,000 6 × 12 in. concrete cylinders, about 1,000 2 × 4 in. cylinders of 1-3 standard sand mortar, and about 500 miscellaneous tests. Tests have been under way for 3½ years; some of the later tests are incomplete as this report is written.

The following are the principal conclusions from this investigation:—

(1) There was no essential discrepancy between the indications of the compression tests of 1-5 concrete in the form of 6 × 12 in. cylinders and the tests on 1-3 standard Ottawa sand mortar in 2 × 4 in. cylinders.

(2) Compression tests of concrete and mortar showed a deterioration in strength with storage of cement for all samples, for all conditions and periods of storage and at all test ages. The deterioration was greatest for the samples stored in the shed in yard, and least for the samples stored in the laboratory. The basement storage was nearly as severe as outdoors. The deterioration was greater during the first 3 months than for later 3-month periods. A greater deterioration was found in the tests made at the age of 7 days than at 28 days and later test ages.

(3) After 3-month storage in shed in yard the cement had 80 per cent. of its original strength; after 6-month storage, 71 per cent.; after 1-year, 61 per cent.; after 2-year, 40 per cent. The deterioration was probably greater in these tests than would be found in a larger lot of cement stored under similar conditions.

(4) The effect of storage of cement on the concrete or mortar strength is largely a question of the *age at which concrete or mortar is tested.* The average concrete strength of cement stored in shed in yard *when tested at 7 days* (for all periods of storage) is 64 per cent. of the strength when received from the warehouse; at 28 days, 71 per cent.; at 6 months, 78 per cent.; at 1 year, 82 per cent., and at 2 years, 85 per cent. A somewhat similar relation is found for other storage conditions. It is a matter of the utmost importance to note that the strength of concrete is not *permanently* reduced to the low values found in the 7- and 28-day tests.

(5) For periods up to 1½ years there was no marked difference in the quality of cement stored in cloth and in paper sacks. The two brands of paper sacks gave almost identical results.

(6) Only a slight advantage was found from the protection of cement in cloth sacks which were covered by thin layers of Portland cement or hydrated lime. The results obtained do not justify the cost of this method of protecting cement stored in sacks.

(7) The most favourable storage condition (in laboratory) and the least favourable (in basement and shed) gave strengths of the same order of magnitude; indicating that the possibilities of improving the storage condition of cement *in sacks* in this climate is rather limited. The *storage period* and the *age* of the concrete or mortar at test are of greater importance than the exact *condition of storage*, so long as the cement is protected from direct contact with moisture.

(8) Storage of cement prolongs the time of initial and final setting.

(10) The normal consistency was only slightly affected by storage.

(12) The deterioration of cement in storage appears to be due to absorption of atmospheric moisture, causing a partial hydration, which exhibits itself in reducing the early strength of the concrete and prolonging the time of setting.

Only a negligible quantity of lumps were formed up to 1 year storage. The lumps found in the sacks after storage for more than 1 year presents a puzzling feature of such tests; they were generally discarded before testing the cement. Tests on concrete using only broken lumps as cement gave considerable strength.

This series of tests did not include bulk storage of cement, however, there is reason to believe that cement may be stored in bulk for long periods without materially affecting its concrete and mortar-making qualities.

# THE CONCRETE SECTION AT THE ROYAL AGRICULTURAL SHOW.

ALTHOUGH concrete itself is no new thing, its application for use on the farm and estate to any considerable degree is a recent development. The reason is obvious. Although the employment of concrete in this direction was, to a limited extent, in operation some ten or fifteen years ago, when its remarkable properties were appreciated only by the few, it was during the period affected by the war that it received its greatest impetus owing to the shortage of timber, bricks, iron and steel. This gave concrete the opportunity of proving itself in the eyes of the many as far as what might be termed its minor uses are concerned, and it is a remarkable fact that those who have once adopted concrete for almost any purpose, as a substitute for other constructional materials, rarely, if ever, return to their former methods since experience enables them more fully to appreciate the superiority of concrete in every respect. Indeed, concrete has passed beyond the stage when it was regarded only as a substitute, and has now entered into its own domain as a building material in itself, and nothing, perhaps, in constructional methods is more striking than the ever-increasing variety of uses to which concrete is now being applied, not only for agricultural purposes, but also in the home and garden, on the railway, and in works by public authorities.

The wide possibilities of concrete were demonstrated in a particularly effective manner in the concrete section of the Royal Agricultural Show recently held at Darlington. This section consisted of the stand of the Concrete Utilities Bureau, of 35, Great St. Helens, E.C.3., one of the largest in the Show, and those of eleven other firms exhibiting modern concrete machinery and concrete articles, while in another part Messrs. Tidnam's, Ltd., of Wisbech, displayed a variety of their well-known products.

The collection on the stand of the Concrete Utilities Bureau, like the permanent exhibition at 143, Grosvenor Road, London, arranged by the same organisation, was purely educational in character and was intended not to advertise the goods of any particular firm, but to be helpful and suggestive—helpful, since a far better idea of the character and value of an article or a structure may be obtained from actual inspection of the real thing than by reading about it, and suggestive, in that each of the products exhibited was only a type upon which many others might be based.

To the passer-by the main entrance presented a very attractive appearance, by reason of a display of flowers and foliage—roses and other climbing plants, supported by concrete posts and " rose ladders," or clinging in festoons to chains slung between concrete poles, garden vases and pedestals in concrete, the former filled with a choice collection of plants. These exhibits were typical and not only demonstrated the suitability of concrete for decorative purposes in the garden but disposed of the fallacy that vegetation does not take kindly to concrete.

The more utilitarian side of concrete in this connection was illustrated by a concrete slab path at the entrance, bordered with ornamental edging tiles, and by the fencing with which the whole stand was enclosed, wires being attached to some of the posts and serving as supports for fruit trees in the form of espaliers.

The construction of the Stand itself was very similar to that at Cardiff, last year, the roof, supported on concrete block columns being covered with Poilite sheets, tiles and slates supplied by Messrs. Bell's, United Asbestos Company, Ltd., while the two walls, forming one corner, were pebble-dashed externally as an illustration of one of the many pleasing surface effects which may be produced in concrete.

The majority of the exhibits were naturally examples of the use of concrete for agricultural purposes, and these were many and varied.

In the opinion of agricultural experts to-day, the question of ensilage has not received the attention in this country which its importance demands, and if food production is to be increased in the ratio which the necessities of the nation render imperative, the practice of ensilage must take a prominent place in the agricultural methods of the future. It is therefore interesting to note that in the bureau and adjacent stands three examples of concrete silos were exhibited. One, just inside the main entrance, was a reinforced monolithic silo erected by Mr. W. Hopkins, consulting engineer, of Leonard Stanley, Glos., who gave demonstrations daily of silo construction on his method and with his patent apparatus. This silo is shown in *Fig.* 3. Another silo section consisted of pre-cast concrete blocks made by Messrs. Stothert and Pitt, Ltd., of 38, Victoria Street, S.W.1, and the third silo was to be seen on the stand of Messrs. Henry Wilde, of 8, Manor Park, Lewisham, S.E.13, and was built of pre-cast blocks, for which they have a special machine. This silo was reinforced at

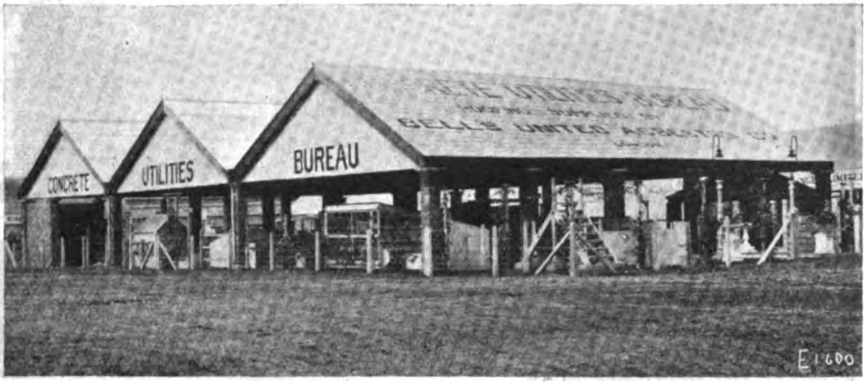

FIG. 1. THE CONCRETE UTILITIES BUREAU STAND.

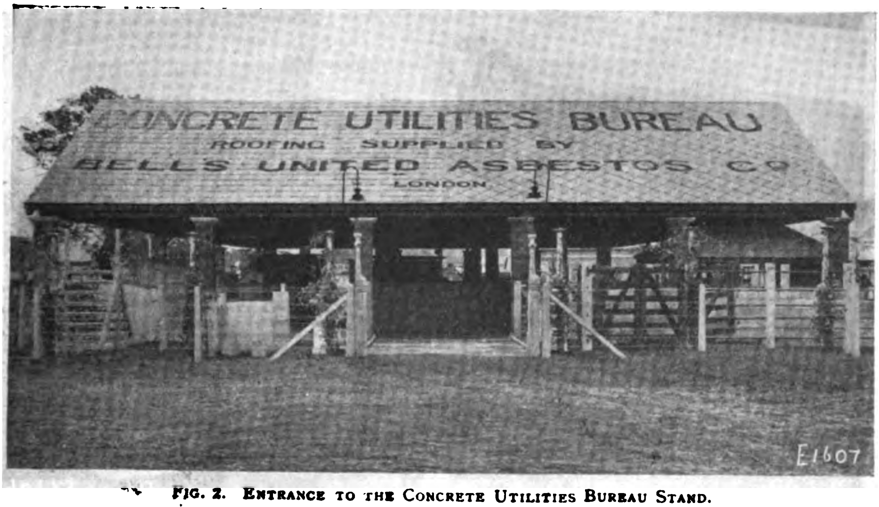

FIG. 2. ENTRANCE TO THE CONCRETE UTILITIES BUREAU STAND.

every course, and had a ¾-in. coating of Portland cement mortar inside so as to render the structure water-proof, and facilitate the settling down of the silage.

The advantages of concrete for farm buildings are well established, and two excellent examples of cow stalls were shown, one constructed by Mr. W. Hopkins, and the other by the Lilleshall Company, Ltd., Priors Lee Hall, near Shifnal, while an admirable cow manger had been contributed by the Wharf Lane Concrete Co., Ltd., Ilminster, and is seen in *Fig.* 4.

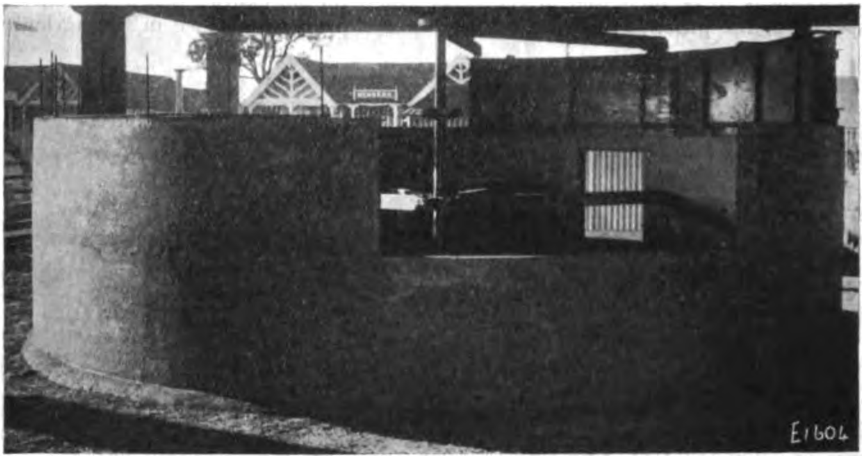

FIG. 3. REINFORCED CONCRETE MONOLITHIC SILO, WITH MOULD IN POSITION ON THE RIGHT

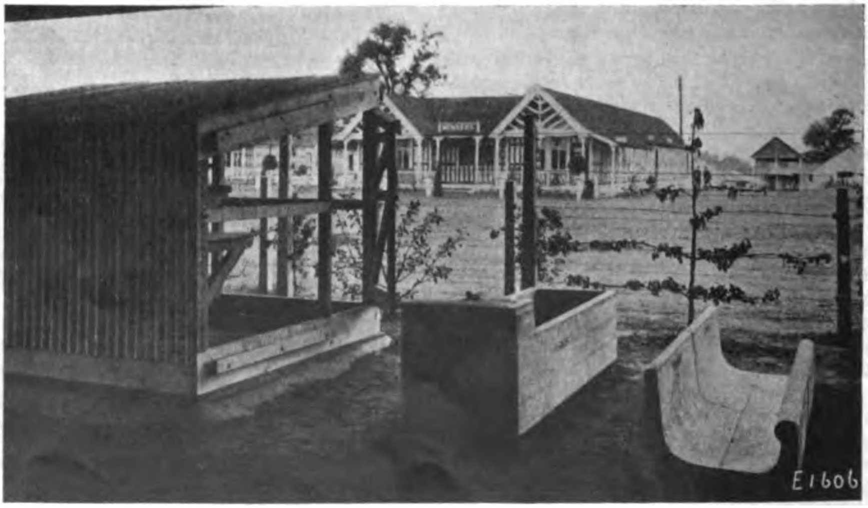

FIG. 4. WATERING TROUGH, COW MANGER AND POULTRY HOUSE, WITH ESPALIER FRUIT TREE.

An exhibit which aroused the interest of a large number of visitors was a pig-sty in concrete, with cement-asbestos roof. The sty, both the sleeping place and the pen, had been moulded in sections which were bolted together, the whole resting on a concrete floor.

The collection contained several novelties. Among these were two poultry houses, both of which were centres of interest. One consisted of a concrete frame with roof and back wall of cement-asbestos sheeting. The other three sides and the door were filled in with poultry netting, and by an ingenious arrangement of cement-asbestos shutters either of the three sides could be closed in, according to the direction of the wind, so that the birds might be protected from draught. The perches were of concrete, and the dropping board of thick cement-asbestos material. *Fig.* 5 shows a back view of this poultry house with the shutters in position, and *Fig.* 6 a front view with the shutters removed.

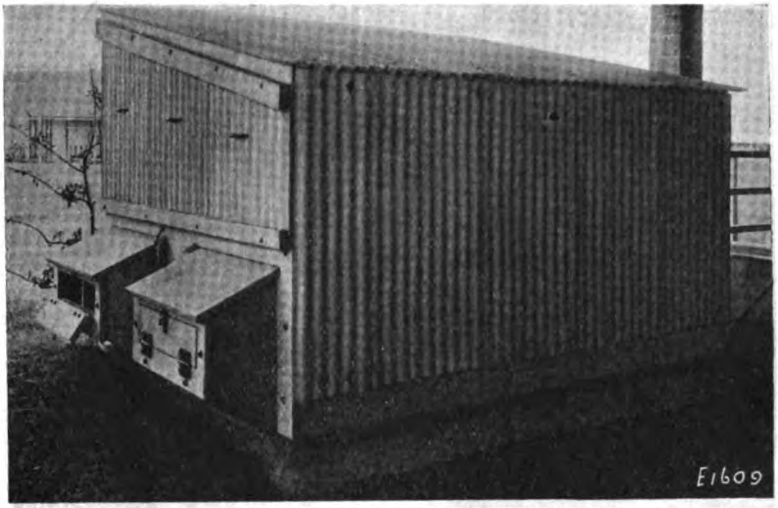

Fig. 5. Poultry House, showing Cement-Asbestos Shutters in position.

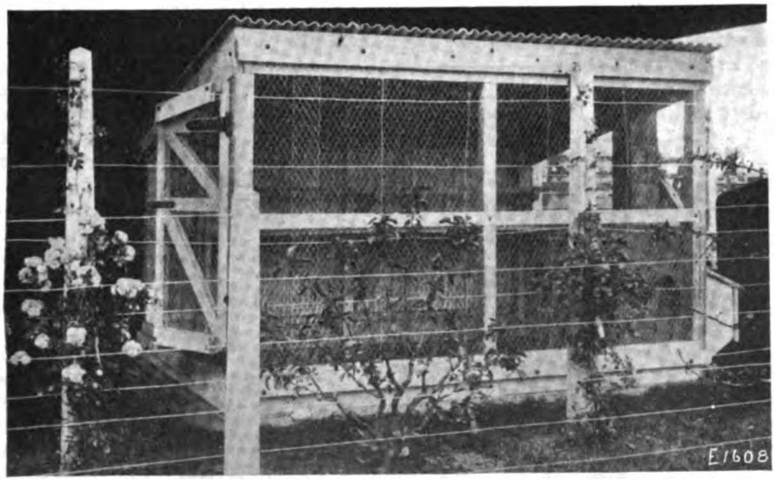

Fig. 6. Front View of Poultry House with all the Shutters removed.

The other poultry house was of quite a different type. The walls were concrete slabs, and the roof again of cement asbestos sheeting. The floor of the house was raised some two feet or so from the ground and underneath was the scratching shed. A sliding concrete door formed the exit, and from it led a concrete poultry ladder to a run formed by concrete posts and wire netting. In the run were two troughs and the

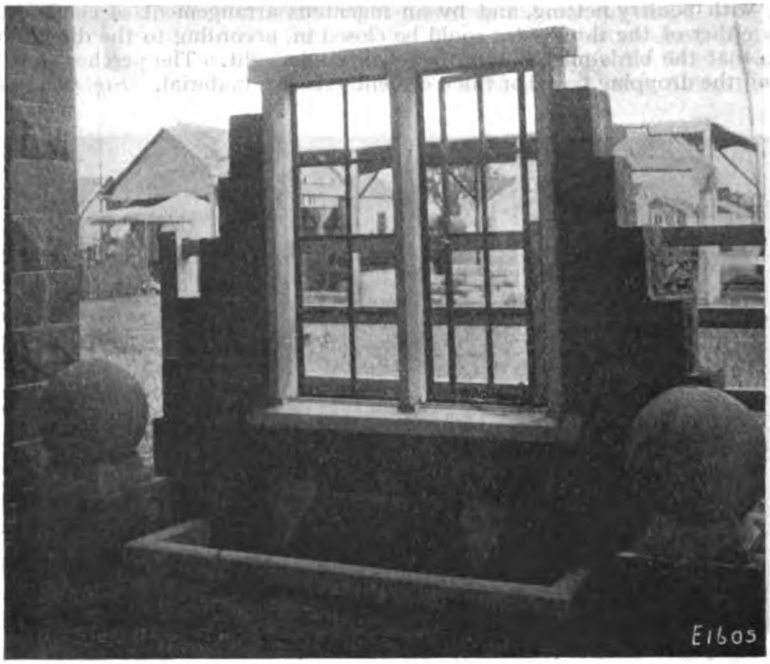

FIG. 7. CONCRETE WINDOW FRAME WITH STEEL SASHES. AT EACH SIDE ARE CONCRETE FINIALS AND IN THE FOREGROUND A CONCRETE FIRE-KERB.

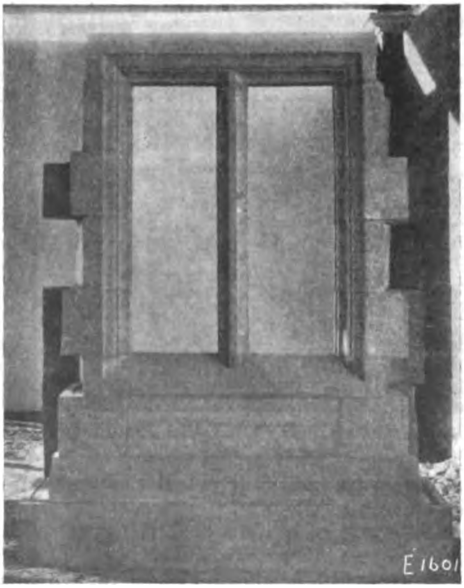

FIG. 8. CONCRETE WINDOW FRAME.

mould in which they were cast. Affixed to the door of this house was what we suppose has never been seen before—a concrete lock, or, to be precise, a concrete lock casing, for which purpose wood is usually employed.

Another novelty was a concrete chicken coop. This exhibit, which excited a good deal of admiration, was exceedingly neat in appearance, had a loose bar in front, which could be raised in order to release the hen, and could be made quite comfortable for both hen and chicks.

Fencing is such an important item on a farm, and concrete has so proved its great value for this purpose, that it was not surprising to find many types on view. These were supplied by Messrs. Girling's Ferro-Concrete Fencing Co., The Lilleshall Co., Ltd., The Wharf Lane Concrete Co., Ltd., and the County Borough of Croydon.

The Wharf Lane Concrete Company contributed an artistic window frame, seen in *Fig.* 8, and two finials for gate posts, shown in *Fig.* 7, which had all the appearance of dressed stone, and which attracted a considerable amount of attention, many people being astonished to learn that they were concrete at all. By the method adopted by this company, any local stone may be imitated so closely as to render it exceedingly difficult to be distinguished from the original.

Since the housing question now occupies a prominent place in the public mind, a range of eight different types of concrete walling had been erected along one side of the stand in order that those who wished might study the various methods of construction. These may be seen in *Fig.* 9. All these were built of blocks made by the concrete machinery firms in the adjacent stands.

The centre of the stand was occupied by a partially erected house. This was built on the cavity wall principle of concrete and breeze blocks supplied by Messrs. W. Ferguson and Son, of Newcastle-on-Tyne, who also supplied the ornamental vases and pedestals to which reference has already been made, as well as a couple of sundials.

Another exhibit of interest to the building trade was a shed erected for the Redhill Tile Co., Ltd., roofed and flanked with red concrete inter-locking tiles made on the Vickers machine.

Messrs. Bell's United Asbestos Co., Ltd., exhibited examples of their "Hurcan" system of building which they are adopting in their garden village at Harefield. Under the most recent development of this system, a wall consists of piers constructed of specially shaped concrete bricks, and two leaves of "Hurcan" slabs with a cavity between. The slabs are of concrete, faced with a coating of cement-asbestos material incorporated when the slabs are moulded. The result is a structure with a very pleasing surface.

For the benefit of surveyors and representatives of municipal authorities, a section of concrete roadway had been laid down, so arranged as to show each stage of the work This exhibit, although not spectacular, was of importance, since there can be no doubt that the concrete road is destined to play a prominent part in the future economic and industrial life of the country.

Concrete products for use on the railway were again included in the collection. The Great Western Railway contributed a cattle pen and watering trough ; the North-Eastern Railway a culvert, circular tank, sleeper blocks, sectional hut and hedge steps ; and the London and South Western Railway a pair of artistic lamp posts.

These exhibits were so fascinating that many pages of this journal could be filled with a description of them, but considerations of space forbid more than a simple enumeration of the remainder, but even this, together with the foregoing, will serve to show the scope of the display. These were as follows :—Fencing of many types, garden frame containing living plants, various moulds, pavement gratings, pavement kerbing, sewer pipes, tanks, circular and rectangular troughs, well tubes, window frames and window heads.

It was a happy thought on the part of those responsible for the arrangement of the concrete section to assemble in the proximity of the Concrete Utilities Bureau Stand, ten others exhibiting modern concrete machinery and one illustrating the application of concrete for fencing purposes. The firms represented in these stands were as follows :—

WM. BENSON AND CO., 28, Meanwood Road, Leeds.—This company exhibited the Australia Concrete Block-Making Machine which has already been described in these pages.

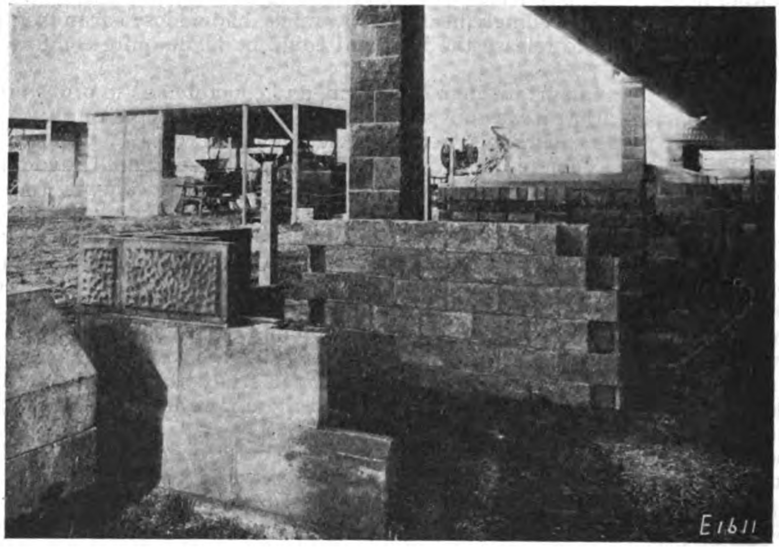

Fig. 9. Various Types of Concrete Walling.

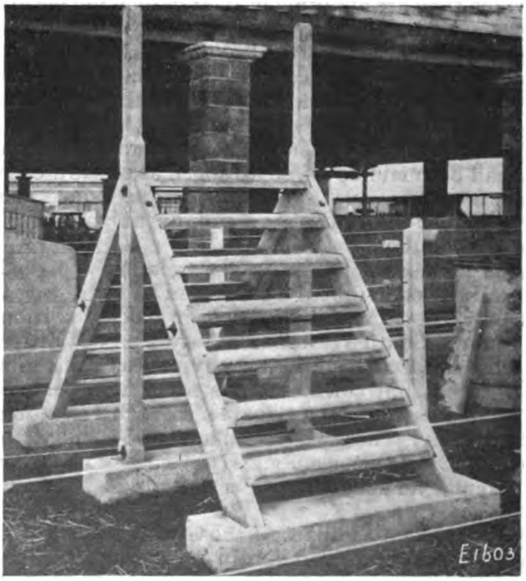

Fig. 10. Concrete Hedge Steps.

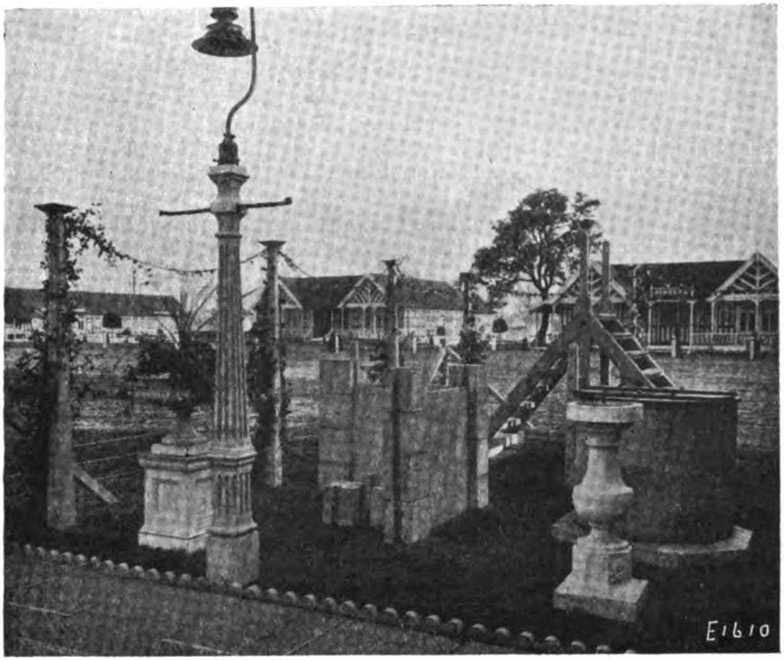

FIG. 11 AN INTERESTING CORNER.

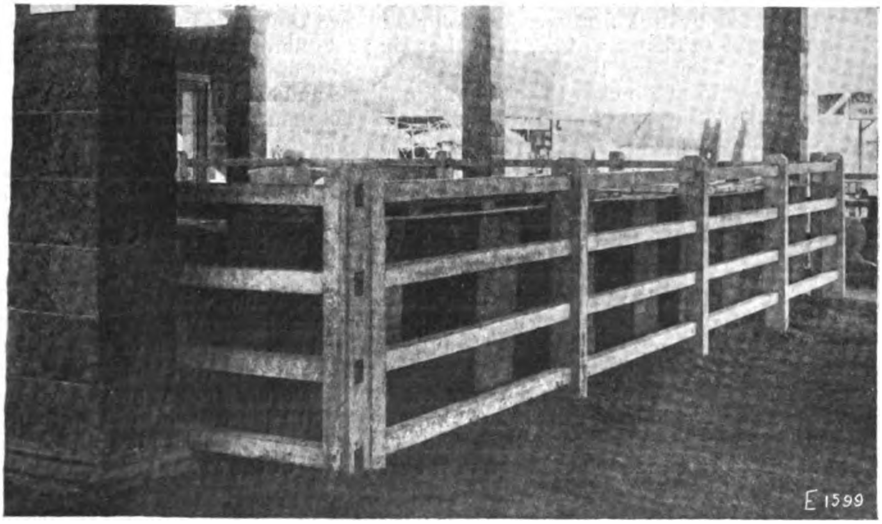

FIG. 12. AN EXAMPLE OF POST AND RAIL FENCING IN CONCRETE.

THE CHANNELLO CONSTRUCTION COMPANY, 8, Warwick Court, Gray's Inn, London, W.C.—Spring Ram and Hand Ram Machines were shown on this stand for making blocks for cavity walls of 6 in., 9 in., and 11 in. in thickness. Any face can be produced on these machines.

GIRLING'S FERRO-CONCRETE FENCING CO., New Howley Park Quarries, Morley, near Leeds.—Here were exhibited Gate Posts and Fence Posts of various descriptions.

R. H. KIRK AND CO., Collingwood House, St. Peters, Newcastle-on-Tyne.—On the machine supplied by this company, heads, sills, etc., up to five feet in length can be made, or, alternatively, by the adoption of metal partition sheets a number of blocks at the same time.

THE LINER CONCRETE MACHINERY CO., Ouseburn Foundry, Maling Street, Newcastle-on-Tyne.—This firm exhibited several machines; (1) a Block, Head and Sill Machine, known as the " Harrison " patent artificial stone machine, for which it is claimed that every unit required in the construction of a house may be made in it; (2) a Revolving Screen; and (3) an ingenious coke-washing machine by which after washing, the lighter and heavier materials are automatically collected separately, and discharged through different chutes.

CHARLES JAMES MANNELL, Petra Place, Poole Hill, Bournemouth. The " Manelite " machinery may be operated by hand or hydraulic power, and makes concrete wall blocks for use in buildings, farm sheds or outhouses.

MESSRS. STOTHERT AND PITT, LTD., 38, Victoria Street, London, S.W.1.—Exhibited Block and Slab-Making Machines, two Mixers and various types of walling slabs.

VICKERS, LTD., Vickers House, Broadway, Westminster, S.W.1.—Four machines were shown at this stand; (1) A Concrete Tile Machine for making interlocking roofing tiles of any desired colour; (2) a Concrete Brick Machine for making six bricks at a time; (3) a Concrete Pipe Machine for making three 3-in. agricultural pipes at each operation; and (4) a machine for making concrete blocks or slabs, either cored or not.

R. G. WHITAKER, LTD., 22, Southwark Bridge Road, London, S.E.1.—On this stand might be seen a machine for producing fence-posts, lintels, corbels, etc.; a concrete brick machine for moulding nine bricks on one pallet in one operation; two machines for making concrete slabs, solid in one case and with two cores in the other.

HENRY WILD, 8, Manor Park, Lewisham, London, S.E.13.—The machines and moulds exhibited by this firm were as follows:—two Concrete Brick Machines, one for making three bricks at a time, the other six; a Concrete Block Machine for producing " anchor " building blocks, a speciality of the Company; Fence-post Moulds; Moulds for Pipes from 4 inches to 5 feet in diameter; and a Silo Block machine. As previously stated, the section of a concrete block silo about twelve feet high had also been erected on this stand.

WINGET, LTD., 24, Grosvenor Gardens, Westminster, S.W.I.—This exhibit was practically the same as that shown by the same firm at the Building Trades Exhibition, at Olympia. It included their ordinary and hand pressure Block and Slab Machines, a Tile Machine, Crusher, three Mixers, Floor Machine, Kerbing Mould, Lintel Mould, Paving Slab Mould, Brick outfit, Elevator, Truck Loader and Pulley.

One feature of the concrete section, of high educational value, was the large number of demonstrations which were carried out daily at frequent intervals. These consisted in the moulding of concrete fence-posts and rails, in the construction of a reinforced concrete silo, and in the operation of the various machines already described. These demonstrations, which were largely attended, were helpful, since concrete workers had the opportunity of comparing their own methods with those of the demonstrators, and they were instructive because those who had no knowledge of concrete or how it was produced, received an object lesson in the simplicity of the operations.

# RECENT BRITISH PATENTS RELATING TO CONCRETE.

*We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Mr. J. Harold Beaumont, Registered Patent Agent, of Messrs. Andrews and Beaumont, 204-6 Bank Chambers, 29 Southampton Buildings, W.C.2. The last article appeared in our issue of April, 1920.—ED.*

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**Concrete Walls.**—*No.* 136,682. *R. D. Atherton,* 2, *Lilac Road, Hale, Chester. Dated January* 17/19.—This invention relates to the method of constructing walls for dwelling-houses, etc., and particularly to the type of structure wherein the side faces of the wall are built up of slabs or sheets and the wall completed by a filling of concrete or the like, and consists in special forms of metal clips or brackets for securing the stanchions and intermediate uprights in their positions, and in particular forms of metal keys or horizontal tie bars and brackets for connecting together the face slabs or units, the metal frame and concrete filling.

FIG 3.

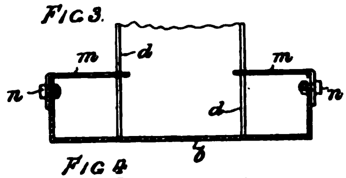


FIG 4

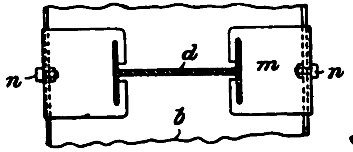


FIG 6

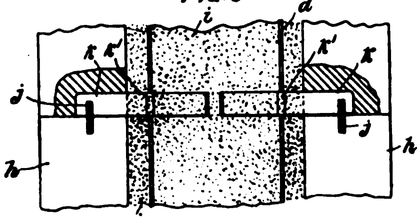
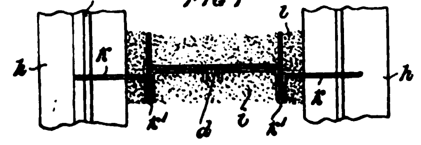


FIG 7



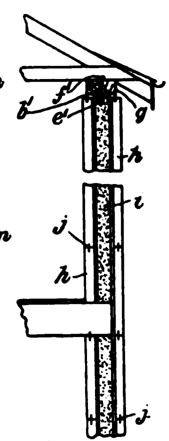


FIG2

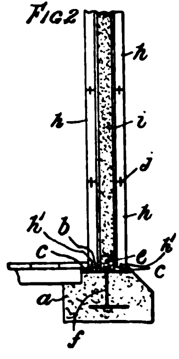


*Fig.* 5 illustrates the method of securing stanchions at intermediate points between the foundation and roof at the angles or corners of the building or structure.

*Figs.* 6 and 7 shew the method of securing the stanchions at intermediate points between the foundation and the roof and also the method of tying the moulded slabs together.

A metallic skeleton frame is first formed in any convenient manner.

On the foundation girder (*b*) is placed a double course of concrete previously prepared, slabs or units (*h*), preferably left rough on their internal surfaces for better adherence of the concrete (*i*) when rammed into the mould formed by such units. The bases and tops of the second double course, slab (*h*), are keyed by horizontal bars (*j*) lying embedded in half grooves formed respectively in the courses immediately below and above such bars. These horizontal bars (*j*) are embraced by clips or brackets each of which consists of a suitably shaped metal bracket (*k*), *Figs.* 6 and 7, having a U bent ($k^1$) to receive and slip over a flange of one of the vertical stanchions (*d*), and an extension or arm formed with a slot to receive one of the horizontal bars (*j*).

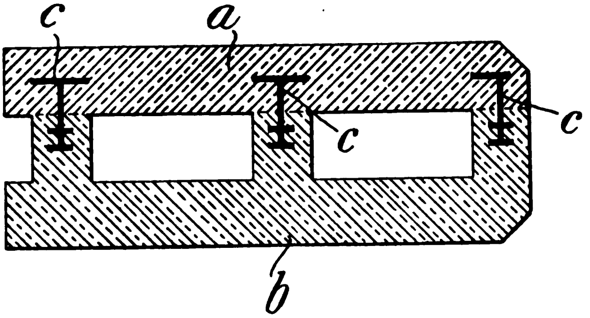
Having thus formed a hollow mould, concrete (*i*) is poured and rammed in the usual way so as to form a solid wall of concrete faced by the previously prepared slabs.

To further secure the stanchions (*d*) or uprights ($d^1$) at intermediate points the form of clip bracket (*m*) shown in *Figs.* 3 and 4 is employed, which at one end it is slotted to slip over and embrace a flange of the stanchion or equivalent H girder, and near the other end is secured by a bolt or bolts (*n*) to the flange of the channel girder, which may either be the foundation girder (*b*) or the top inverted girder ($b^1$), or centre or intermediate girders, similarly employed at any floor.

**Hollow Concrete Blocks.**—*No.* 136,725. *F. B. Smith, The Poplars, Aberavon, Glamorganshire. Dated February* 27/19.—This invention relates to hollow or cavity concrete blocks or slabs built up of two or more classes of concrete, and has for its object to strengthen the line of weakness, *i.e.*, the joint between the different classes of concrete of which the block or slab is made.

This is effected according to the invention by the application and use of metal reinforcements, of any suitable shape, introduced into the block, during manufacture thereof, so as to extend from one class of concrete into another class of concrete.

The inner part (*a*) of the block is made of breeze concrete and the outer part (*b*) of hard concrete, the metal reinforcement (*c*) extending over the junction.



**Moulding Concrete Blocks.**—*No.* 138,044. *H. I. Hooper, 38, Prince's Square, London, W.2. Dated September* 5/19.—An automatic machine for moulding concrete blocks in accordance with this invention comprises the following parts :—A mould fitted with one or more reciprocating plungers for pressing and ejecting the article ; a feed device for delivering a measured charge of material into the mould ; and a pivoted lid adapted automatically to be closed, held in position by a latch and opened after the charge has been compressed, the plunger or plungers being held stationary for a sufficient period to enable the lid to open fully before moving further for ejection.

The plunger F carries a rod (*f*) which slides through a gland upon the frame plate and carries at its lower end a roller ($f^1$) which bears upon the cam ($c^1$). A loose pallet board G rests on the top of the plunger F. The lid H is provided with a pallet ($H^2$) and carries a catch ($h^1$) adapted to engage a latch (*i*) formed at the end of a lever (*I*). This lever is provided at its lower end with a bent portion ($i^2$) which projects into the path of a cam-piece ($c^4$) attached to the cam ($c^1$), and is normally held in closed position by a spring ($i^4$). The lid is pivoted to an ear (*J*) upon the moulding receptacle (*A*) and is provided with a rearwardly extending arm ($H^1$), the end of which is provided with a pin (*h*) engaged through a slot by a link (*K*) pivoted to a sliding rod (*L*), the lower end of which carries a roller (*l*) engaging the cam ($c^2$).

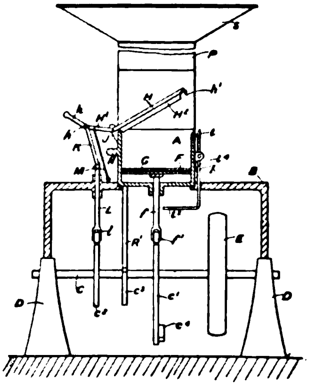


FIG. 1.

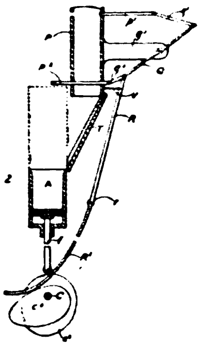


FIG 2

The cam ($c^1$) is provided with a concentric portion to enable the lid to open fully prior to the continued upward movement of the plunger for the purpose of ejection.

A spring (*M*) tends to hold the lid in the open position which is determined by a stop (*N*).

The link (*K*) is provided with an extension (*K*) which can be actuated in cases of emergency to release the lid and allow it to fly open under the action of its spring.

The feed mechanism comprises a shoot (*P*), *Fig.* 2, provided with doors ($p^1$, $p^2$)

connected by links ($q^1$, $q^2$) to a lever ($Q$) which is pivoted to a fixed arm ($q^3$). A lever ($R$) is pivoted to the link ($q^2$) and arm ($Q$) and also to a fixed pin ($r$); the lower end ($R^1$) of this lever is bent to engage the shoot feed cam ($C^3$).

The shoot is fed from a hopper ($S$), and a deflector plate ($T$) is provided to guide the fed material into the moulding receptacle ($A$).

In the operation of the machine the upper door ($p^1$) first closes, and the lower door ($p^2$) then opens to deliver the charge into the moulding receptacle. The hinged lid ($H$) is then closed and held closed by the latch ($i$) while the plunger ($F$) moves upward to compress the material in the mould; the latch is now opened by the cam-piece ($c^4$) to release the lid which flies open under the action of its spring, and further upward movement of the plunger causes the moulded article to be ejected from the mould, whence it is removed for the further stage of hardening and drying. The end ($R^1$) of the lever ($R$) is maintained in contact with the cam ($c^3$) by a spring ($V$).

**Concrete Walls and the Like.**—*No.* 138,159. *G. Coe,* 97, *Altenburg Gardens, Clapham Common, London, S.W.*11. *Dated January* 29/19.—This invention relates to a unit system of construction in which hollow units are first placed or built up into position and the hollows of the units are then filled up with wet concrete.

In building a wall in accordance with the invention, a required number of correctly designed and shaped units are prepared in readiness and allowed to harden, while foundations and the like are prepared. When the work is convenient for starting the units are built up, course after course, one above another, dry jointed, until a convenient height of about five or six courses or units is obtained. The cavities in units are kept carefully in line forming continuous cavities passing through the units from bottom to top, and suitable reinforcement is then placed into the cavities to a convenient height.

The cavities are then filled up with concrete, the operation is then repeated for another suitable height, and so on to the completion of the structure, varying directions of the work, such as floors and the like, will be taken into account and proceeded with at the proper time during the course of construction.

Provision may be made in the foundations, by providing reinforcement projecting from the foundation or floor in the required position to coincide with the cavities in units, for the purpose of mechanical bond or anchorage as required. Structures may be formed partly of ordinary reinforced concrete and partly of this unit system; that is to say, this unit system may be used in combination with ordinary reinforced concrete where required.

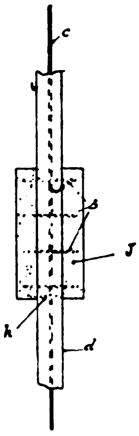


FIG 4a

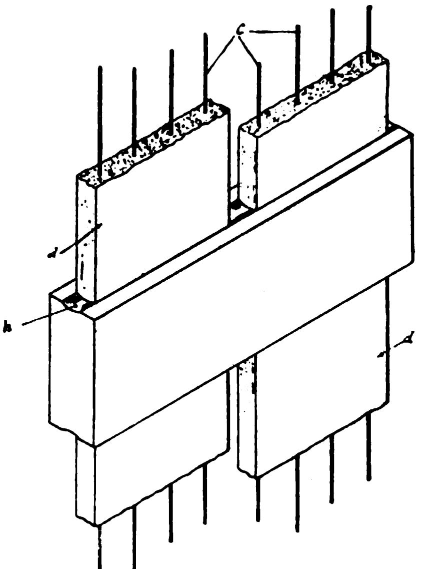


FIG 4

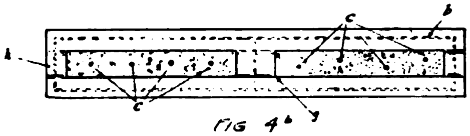


FIG 4b

Various shaped units are illustrated other than that in *Fig.* 4, which is a single unit with the vertical ribs or pillars ($d$) shown passing through unit as they would be after the cavities of units have been filled with concrete. The ribs are shown extended beyond the unit, for clearness. This type of unit is preferably built bonded, or brake jointed as previously described, and reinforced with an internal reinforcement as shown at ($b$) on *Fig.* 4*a* and *Fig.* 4*b*.

**Concrete Walls and Fences.**—*No.* 138,161. *J. S. Baines, " Glenart," Coronation Road, Great Crosby, Lancaster. Dated January* 31/19.—In building slab walls and fences in accordance with this invention a concrete block (*A*) is cast *in situ* in a hole. in the ground. These holes are accurately laid out and dug in the line of the fence Vertical rods (*B*) are embedded in the blocks and are threaded through in *Figs*. 4, 5 and 6, a long metal bar (*E*) having holes at intervals for the rods. These are drilled according to template.

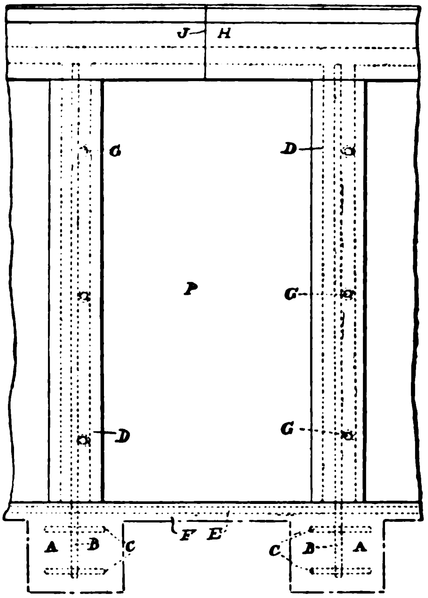


*Fig. 1.*

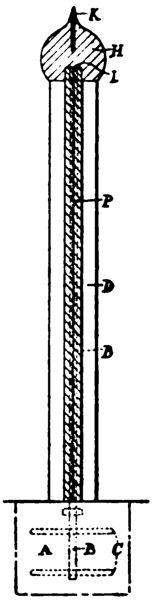


*Fig. 2.*

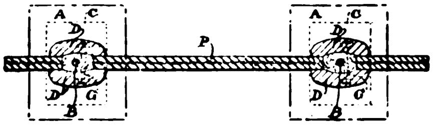


*Fig. 3.*

A coping or entablature (*H*) is placed on top of the wall and posts, and has grooves (*I*) into which the slabs project, and the latter are well grouted so as to hold fast in the plinth. The plinth joints (*J*) are preferably in the centre between two posts. In this coping a metal blade (*K*) is preferably placed, which can be either serrated or plain so as to make it more difficult for people to climb the fence or wall.

The pits are dug. filled with concrete to a short distance up, and then the lower plates (*C*) and the bolts are placed in position. It is then filled up for a further distance when the second plates (*C*) are placed in position, the rods being held carefully at right distances from the top. Longitudinal plate (*E*) is now inserted and the concrete filled in around this. The plates (*P*), while this concrete is still soft, are put into position as are also the cheeks (*D*), and these are bolted together by the bolts (*G*). The coping (*H*) is turned upside down, the bottom and the groove well coated with fine cement and then, while the cement is still soft and wet, it is reversed and pressed down on to the plates and posts, or, if preferred, the plates and the posts can be coated with the cement and then the plinth pressed down on to them and the extra cement in each case is carefully wiped off.

**Concrete Roads and the Like.**—*No.* 139,575. *The British Reinforced Concrete Engineering Co., Ltd., and E. B. Hall, all of* 1, *Dickinson Street, Manchester. Dated February* 11/19.—The object of the present invention is so to form the surface of the concrete that the asphalt or other topping may become practically " keyed " or

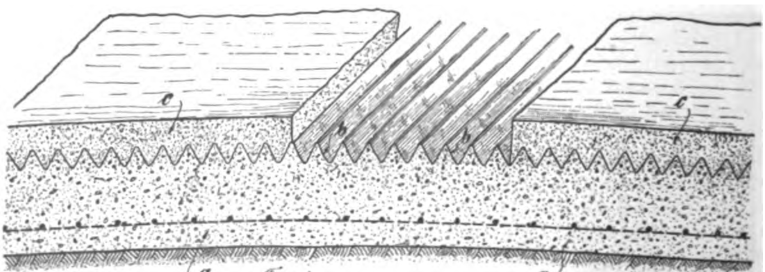


*Fig. 1.*

mechanically held to the concrete, thereby diminishing the possibility of its leaving the concrete and helping to maintain an even road surface.

According to the invention, the surface of the concrete (*a*), while the concrete is in a pliable state and after being smoothed out, is formed with a multiplicity of V-grooves (*b*). After the concrete has set hard, the asphalt, macadam or other topping (*c*) is laid over the concrete and rolled into the V-grooves, the form of the grooves causing the topping to become wedged or keyed therein.

The depth of the grooves may vary, but a depth of about 1½ in. will usually serve, and the angle formed by the sides of each groove will preferably be about 60°.

The grooves will be formed by any suitable apparatus, such as a heavy roller, or a drag device, producing the grooves in continuous lengths on being travelled over the soft concrete.

To further help in keying the surfacing material to the concrete, the sides of the grooves may be undercut, or serrated, suitable tools being provided for such purpose.

Instead of extending longitudinally of the road, the grooves may extend transversely or diagonally, or be arranged to any desired plan.

Instead of being arranged over the whole surface of the road, the grooves may only partly cover the road, *i.e.*, be arranged at intervals.

**Hollow Block Concrete Walls and Floors.**—*No.* 140,636. *H. K. Dyson*, 10, *Old Burlington Street, London, W.*1. *Dated May* 7/19.—This invention relates to floors, walls, etc., formed by casting cement or concrete beams between hollow blocks formed with outstanding ribs, which when placed in abutment with the ribs parallel form closed channels with inlet passages into which a reinforced cement or concrete beam can be cast without the need of centering below the joints of the blocks parallel to the ribs.

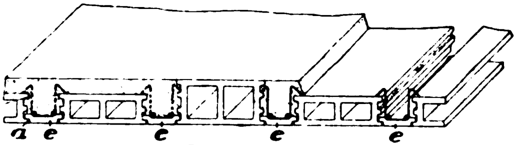


Fig 13

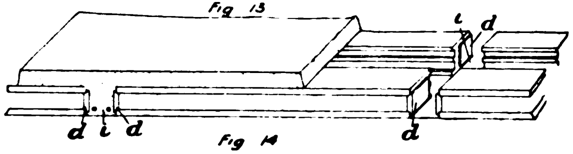


Fig 14

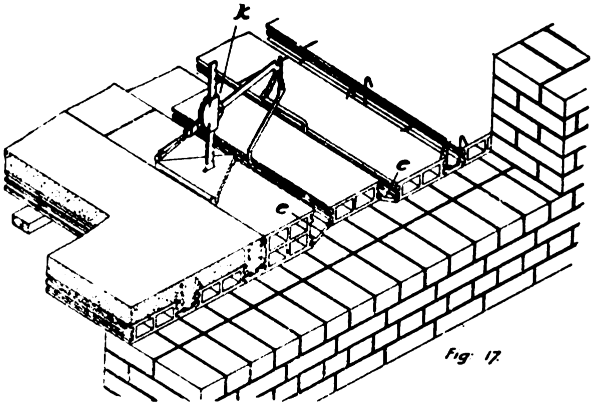


Fig 17

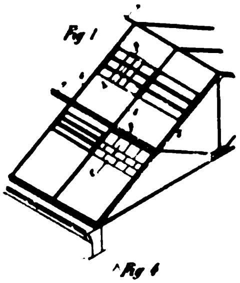
In walls or floors of this type constructed in accordance with the invention, concrete or like plugs are employed to close the cavities at the ends of the blocks in a direction at right angles to the ribs therein.

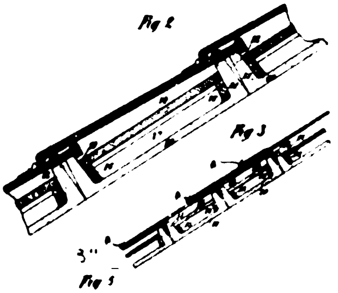
In some cases in which it is desired to provide a wider reinforced concrete beam than is given by the channels between contacting blocks, soffit tiles are employed which engage in the slot between two successive ribs near the bottom of the hollow blocks.

Reinforcing wires (*g*) are inserted in the crevices formed by the grooves which are then filled with concrete. It will be seen that the grooves serve to house the reinforcement and retain it in place, being preferably positioned according to the most advantageous position of the reinforcement wires; but no broad claim is made to this feature. The concrete may be laid so as to cover all the blocks; or deeper blocks may be interposed as shown in *Fig.* 13. *Fig.* 14 shows the blocks, spaced apart endwise in the known manner for the formation of a further system of transverse or main beams in the spaces (*i*) and plugs (*d*) covering the block cavities. In this case the previous longitudinal beams become secondary beams. In *Fig.* 17 a device is shown for inserting the last block (*k*) and soffit tiles (*e*) in a flooring when these cannot be slid into place.

**Reinforced Concrete Roofs.**—*No.* 138,182. *J. F. J. Peeters, 71, rue de la Clinique, Brussels, Belgium. Dated February* 24/19.—This invention comprises an improved reinforced concrete roof built up of pre-cast units.

On the purlins (7) rest light T irons (8) supporting reinforced concrete slabs (10), provided at their long edges with upwardly directed ribs (11), longitudinally extending through the whole length of the slab and sloping in such a manner that between two adjacent ribs (11) a wedge-shaped space (12) is left as shown in *Figs.* 2 and 3. When making use of tiles, this space is filled with cement which connects the adjacent slabs. When slates are used, the fastening hooks (18), maintaining the slates in place, are engaged into said spaces (12) which are also filled afterwards with cement (*Fig.* 3). The hooks (18) securing the slates in position are disposed in alternate relation with respect to each other in the various courses of slates.





A double air space is provided between the inner slabs (10) and the tiles by making use of intermediate slabs of reinforced concrete (14) resting on projections (15) made of concrete, which are preferably made integral with the slabs (10). The small remaining space (19) is filled with cement.

**Concrete Tunnel Linings, etc.**—*No.* 139,314. *F. E. Walker, 51, Sherwood Street, and J. R. Betts, Elm House, Nottingham Road, both of Mansfield, Nottingham. Dated March* 13/19.—Tunnel linings made in accordance with this invention are formed of concrete blocks reinforced by metal channels, tees and angles. At each corner of the block are placed metal channels (*a*), while in the middle of the top and bottom edges tee section bars (*b*) are placed, the channels (*a*) and the tees (*b*) being connected by diagonally placed angle bars (*c*), bolted, riveted or otherwise suitably secured thereto. If desired, in order to give additional strength, joists or channels (*d*) running from side to side of the block may be provided. Before the concrete is cast around the reinforcement, wooden plugs (*e*) (indicated in dotted lines) are placed in the channels (*a*) and the tees (*b*) and are removed when the concrete is set, thus leaving handholes through which bolts can be inserted and passed through holes drilled in the top and side of the channels or through the upper flange of the tee in order to connect one section with the next either above or below it or alongside. In connecting several sections together they are preferably arranged to break joint either vertically or horizontally, thus a channel (*a*) in one section would be secured to a tee (*b*) in the next section.

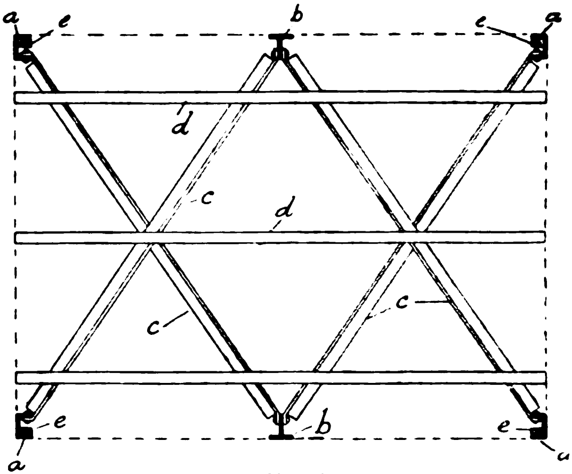


FIG 3

# THE CONCRETE INSTITUTE.

## MONTHLY NOTES.

By the SECRETARY.

### SEMI-PERMANENT BUILDINGS, ACTON, W., FOR THE MINISTRY OF PENSIONS.

*Mr. J. G. West, of H.M. Office of Works, has kindly furnished the following particulars of matters of interest in connection with the semi-permanent buildings at Acton, W., for the Ministry of Pensions, to be visited by Members of the Concrete Institute on Saturday, September 11th, 1920, at 3 p.m.*

The buildings, in course of erection at Acton Vale comprise three separate blocks: a large office block, a canteen and a boiler house with workshops, etc.

**Main Office Building.**—The main office building, consisting of a ground and four upper storeys, is rectangular on plan, measuring some 540 ft. long, 245 ft. wide and 62 ft. high from the general level of the stancheon bases; when complete, this will provide accommodation for a clerical staff of 5,200 persons.

The structure generally consists of a skeleton steel framing, transmitting all loads to the foundations. The pre-cast concrete staircases are, however, carried by the enclosing brick walls.

The design of the steel framing has been arranged with a view to simple construction; built-up sections and bent pieces having been entirely avoided. The bays are set out to dimensions of 12 ft. 6 in. and 10 ft. and the various parts of the plan are generally multiples of these bays.

The floors are being constructed with light hollow, pre-cast, reinforced concrete slab beams grouted up in position, and the flat roofs are of hollow-tile blocks and reinforced concrete, the object of this construction being to reduce the dead loads to a minimum. Both floor and roof constructions take their bearings on the top of the main steel beams. These steel beams require no shelf angles or concrete haunchings and will be left exposed and painted a suitable tint.

The external walls, except those to staircases and lift enclosures, act only as a covering to the structure and are being built hollow of concrete blocks with an outer thickness of 4½ in. and an inner thickness of 2¼ in., with 2¼ in. cavity between. The two thicknesses are tied together with galvanised ties. The wall panels are carried independently at each floor level on a steel beam and panel, encased solid with concrete. The walling is secured at intervals to the steel stancheons with specially-shaped iron ties embedded in the wall joints and concrete filling to the stancheons. The latter are being encased with concrete only where the nature of the construction renders such treatment necessary; consequently some of the stancheons are being erected unpainted and others painted.

The foundations are of plain concrete and all stancheon bases are secured with long holding-down bolts.

Provision has been made for storing water on the main roof over the lavatory bays in tank rooms, constructed with solid walls carrying an independent roof, as steelwork is not carried up above the main roof level.

The main cornice is of simple design and is anchored down at the rear by means of a continuous steel strap and of anchor bolts embedded in a reinforced concrete lintel spanning the main roof beams.

**The Canteen.**—The canteen is complete with its kitchen, sculleries, stores, etc., under one roof and measures 225 ft. long by 140 ft. wide.

The accommodation has been planned on one floor only and the construction is similar to that in the main office building, but the lantern lights are all formed in the main steel framing, certain stancheons being carried up to a greater height for this purpose.

**The Boiler House.**—The boiler house with its brick chimney shaft, workshops, fuel store, etc., measures 94 ft. by 80 ft. Owing to the peculiar requirements of this one-storey building, it was found that so much solid walling was necessary that the walls were made of solid brickwork throughout, the external elevations being faced with the concrete blocks to match the other buildings. Internal stancheons carry the portion of the roof over the boilers, while over the surrounding workshops, etc., the roofs are carried direct by the walls.

The roofs of all buildings are of similar hollow tile construction.

## CONCRETE AGGREGATES.

In the course of 1919 the Concrete Institute took steps to obtain from various County and Borough engineers and surveyors particulars as to the local aggregates available for use in concrete. So that the information might be systematically co-ordinated, the Institute prepared a list of questions, which it forwarded to these officials, and it is upon these that the information furnished is based.

In some instances the information supplied is but meagre, and there are at present many gaps in regard to sources of supply; but it is proposed to publish month by month some of the particulars and to issue them as far as possible in alphabetical order for greater ease of future reference. The Secretary will be glad to receive further reliable information from surveyors, quarry owners and others interested.

(1) **Aberdeen, County of.**—There is a good deal of gravel in the First or Deer District, but it is not much used for concrete. Within the District, in the parishes of Rathen, Lonmay, and Longside, there is a good deal of suitable gravel, but it is not much employed.

(2) **Antrim County.**—The principal materials used here for concrete are broken stones, from any of the numerous local quarries (some of them of considerable importance); and sand from local sand pits, the sea beach or from the shore of Lough Neagh. The available rock is, in almost every case, basalt.

(3) **Argyll (Mid) County.**—Unlimited supplies of rock, of various qualities, but these require to be crushed. There are a few rivers where very good gravel can be obtained, sufficiently small, but the units are all more or less spherical and therefore " not of much service except for foundation work." (See later also " KINTYRE.")

(4) **Armagh County.**—Not much gravel or other loose material available; but there is any amount of granite, whinstone, silurian and limestone rock, which, when broken, " makes excellent material for concrete."

## GENERAL NOTES.

**Lectures.**—A suggestion has been made that a special course of lectures might be arranged by the Concrete Institute for the benefit of ex-soldiers whose theoretical training has been interrupted by the War. The Council will be glad to hear from its ex-soldier members, whether they would be prepared to attend such a Course, which would be held in the evenings, and for which no charge would be made.

**Examinations.**—The next Examinations of the Concrete Institute for Graduateship and Associate Membership will be held in London and Salford on Thursday and Friday, October 14th and 15th, 1920. For a copy of the questions set in May, 1920, for Part I. (Graduateship) and Part II. (Associate-Membership), price 1s., and for all other information, apply to the Secretary of the Concrete Institute, Denison House, 296, Vauxhall Bridge Road, London, S.W.1.

**" A Standard Specification for Reinforced Concrete Work."**—This Specification, which has been several years under preparation by the Concrete Institute, has now been published (price, 1s. 7d., post free), and is to be obtained from the Offices of the Institute. The Specification gives in a concise form all the essential clauses that are required in a building or engineering contract, and its adoption will provide a guarantee for the efficient execution of the work.

**Standard Notation for Engineering Formulæ.**—With a view of cheapening the cost of printing mathematical equations, and with a view to facilitating the reproduction of mathematical equations on the typewriter, the Concrete Institute have recently suggested that those writers who employ :—

(1) The high point as the decimal separatrix (example, $3{\cdot}7 = 3 +$ seven-tenths) ;

(2) The middle point as the sign of multiplication (example, $m \cdot r = m$ multiplied by r) ;

(3) The low point as the sign of abbreviation (example, B.H.P. = Brake horse power), may avoid the use of subscript letters, and write the qualifying letters on the line of printing, $m = Es/Ec$, where $m$ = modular ratio, $Es$ = Elastic modulus of steel, $Ec$ = Elastic modulus of concrete.

The high point, or turned point, is the new British decimal point. (See treatise by Legros and Grant on Typographical Printing Surfaces).

The middle point is the usual sign of multiplication in American engineering textbooks, and it is also used in Germany.

The low point, or period, is the international sign of an abbreviated word.

If the above suggestions are adopted subscript *letters* can be eliminated entirely.

These suggestions are intended to supplement the recommendations given in detail in the recently published Report of the Concrete Institute on " Standard Notation for Engineering Formulæ."

# THE VENTILATION OF CONCRETE BUILDINGS.

### By EDWARD L. JOSEPH, M.I.E.E., F.C.S.

*Abstract from a paper read at the Ninety-sixth Ordinary General Meeting of the Concrete Institute on June 10th, 1920.*

*Introduction.*—The modern trend towards the use of reinforced concrete in the construction of buildings for works, offices, and public institutions calls for very careful considertaions as regards the efficient ventilation of these structures. The term " ventilation " will, in this paper, be taken to include heating and otherwise cleaning or purifying the air where the same is required.

The modern concrete building offers in its finished state an ideal structure as regards light, cleanliness and strength and an efficient system of ventilation.

Thanks to the lack of complication, from a ventilating point of view, of a concrete building, the ventilating engineer car have a comparatively straightforward task in the design of a really efficient system. The simplicity of the scheme and the consequent ease of carrying it out will be much accentuated if the ventilation work be carried out simultaneously with the erection of the building.

*Systems.*—Generally speaking, there are four outstanding systems in ventilating practice :—(1) The Plenum System ; (2) The Exhaust System ; (3) The Plenum Exhaust System ; (4) The Recirculating System.

*Heat Losses.*—In determining the capacity of the plant required the following points must be first considered :—

1. The total heat-radiating surfaces of the different materials exposed to the air at a temperature lower than that at which the air of the building is to be maintained. This item includes floors as well as walls and roofs.

2. The coefficient of heat transmission for each of these various materials. This unit is expressed in British Thermal Units (B.T.U.) per sq. ft. per degree Fahr. difference of temperature and varies from 1·2 for common single glass windows to 0·10 for wood or hard ground or concrete.

The coefficients of heat transmission per degree Fahr. difference for ordinary concrete walls of various thicknesses are given, on the average, as follows :—

| Thickness of Wall in inches. | Coefficient of heat transmission B.Th.U. per degree Fahr. diff. in temp. |
|---|---|
| 4 | 0·65 |
| 6 | 0·56 |
| 8 | 0·48 |
| 12 | 0·41 |
| 16 | 0·35 |

In regard to heat losses through walls, etc., of reinforced work no actual data have been available to the author, but the above table would appear to need only slight revision for such, and even these revised figures would naturally vary for each particular system of construction.

*Advantages of Concrete Buildings.*—Concrete buildings offer many advantages over other buildings to the heating and ventilating engineer, and principal amongst them are the following :—

(*a*) Low heat losses.
(*b*) Easy and excellent erection of ductwork.

And it is now proposed to deal with these separately.

*Heat Losses.*—It will be seen from the table given at the beginning of the paper that the coefficient of heat transmission expressed in British Thermal Units per degree Fahr. difference in temperature between the interior and exterior temperatures is very favourable for concrete buildings. The advantage of this fact shows itself in two ways. Firstly, to obtain a constant working temperature such as is usually required in a factory—*i.e.*, 60° Fahr., the heat lost by radiation being reasonable, the boiler capacity can also be normal in keeping therewith, and the fuel consumption for heating purposes can be reduced to an economical basis. Secondly, and no less important, the initial outlay for the heating and ventilating plant can be kept within reasonable limits and a perfectly efficient and modern plant installed with a minimum of expense.

The interior of the building also will not be affected so rapidly by sudden changes of external conditions, and with reasonable manipulation of the plant the same average conditions may be maintained all the year round. This desirable condition is the direct result of the superior quality of a concrete building in regard to what we may term its " tightness " or " impermeability."

*Erection.*—The erection of plant in a concrete building offers excellent opportunities for careful consideration by the designer. It may be quite possible after a structure is completed for much unnecessary time and money to be spent in making suitable provision for the hanging of electric mains, steam or hot-water pipes, and the distributing ductwork of the air-purifying installation. If, however, this point be carefully considered whilst the building is being designed, both time and money will be saved, in addition to preventing the objectionable effects from electrolysis and surface disintegration, by having to cut into the finished concrete.

The author is of opinion that by far the best method he has met with for dealing with this question is that one devised by Messrs. Burnard Geen and Brierley, whereby cored holes are left at equal and convenient intervals through all concrete beams so that either hangers can be fixed through these holes for large stuff or the smaller pipes can be passed through these holes as their supports. The former method would appear to be the better, as perfect symmetry results and the individual erections are readily available for inspection, repair or replacement.

This question of erection is really of much more importance than might appear at first sight, and unless such a plan as Messrs. Geen and Brierley's system be adopted, it is easy to conceive of many hundreds of pounds being wasted in needless erection work of a large building, which is, of course, the point of view of the heating and ventilating engineer, quite apart from the incalculable damage which might result from tampering with the permanent structure. In a finished building the usual alternative would be to provide a form of hanger which depends for its support on a clamping action.

Another advantage offered by a concrete building is in the erection of the main and distributing ducts. These can most satisfactorily be formed in the concrete itself, thus saving both time and money and obviating the necessity for ductwork appearing on the surface or having to be cased round after erection. The ducts so formed are perfectly satisfactory. The correct coefficience for the skin friction of concrete must be borne in mind when designing them. (A very good example of ducts formed in concrete was given on a slide on which is shown the ventilating installation of a very large factory.)

Regarding the erection of the main plant. This will follow standard practice, although here again expense can be saved if the various foundations be considered in the first place and formed when the floor of the plant room is prepared.

*Conclusion.*—From the foregoing remarks the need for, and advantages of, a correct system of ventilation in, and properly applied to concrete buildings will be appreciated.

The advantages that the modern concrete buildings offer as regards light, cleanliness, comparative ease of erection and the general "clean" design of the building, make the task of the ventilating engineer a very pleasant one, and with due consideration given to the very important matter of complete co-operation between the designer of the building and the ventilating engineer, an installation can be devised and installed that will reflect credit upon all parties concerned and render a healthy and efficient service to the occupants.

### DISCUSSION.

**The President**, in proposing a vote of thanks to the author, said that with regard to heat losses from concrete buildings, the quantity of heat transmitted in B.Th.U.'s would be proportional to the area of the surface and to the temperature and inversely proportional to the thickness of the material, but the author had given no indication of the thickness of the material. Another point was that there seemed to be a loss of heat wherever it was transmitted across any surface. Experiments seemed to show that two separate thicknesses of concrete would cause a greater drop of temperature than one thickness of concrete equal to the other two combined. In addition to there being a loss of temperature through the solid there seemed to be some loss at the change of surface.

**Major R. Grierson** wished the author had said more about the construction of ducts in concrete buildings, because in putting ducts into buildings during construction the reinforced concrete engineer could aid considerably in the matter of accessibility.

**Mr. J. H. Gibson** said it would have been useful if the author could have enlarged upon the question of frictional resistance of air ducts arranged in concrete.

**Mr. Alan Graham** said that concrete building had made very rapid progress during the last few years, and the impervious nature of concrete made the ventilation of such buildings a great consideration.

**Mr. E. L. Hall** said, with regard to the cost of concrete tubes and ducts as compared with metal ones, that it must not be taken that in making a concrete duct in the walls the whole cost of a metal duct was saved. There was some small cost attached to making the duct in the wall. In the same way, the ducts in the concrete walls often reduced the floor space.

### THE LECTURER'S REPLY.

**Mr. Joseph**, replying to the discussion, said he had endeavoured to appeal to the concrete engineer not as a ventilating engineer but as a maker of concrete buildings. The frictional resistance of ducts made in the concrete walls was, of course, higher than in the case of metal, but it could be reduced by finishing the interior with cement, a simple operation with large ducts but difficult in the case of small ones. The whole point was that in designing ventilation systems, each case must be considered on its merits and the design made accordingly.

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## MEMORANDUM.

**Cement Roofing Tiles.**—The Standardisation Committee have expressed the following opinion upon the conditions under which cement roofing tiles may be used :—

> "We are of opinion that unless proper care is taken in the selection and mixing of materials under proper supervision, cement roofing tiles would, in many cases, prove unsatisfactory. We hesitate to object to their use owing to the economy and possible saving of transport which would be effected in some instances, and we recommend that where their use is proposed, the local authority should secure a proper guarantee from the manufacturers that these tiles will form a durable and strong roof covering."

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

**By OSCAR FABER, O.B.E., D.Sc., etc.**

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER III.—*continued.*

46. From what has been said in p. 45, it is clear that a T-beam may be designed as a rectangular beam of width $B$ and depth $d$ by the methods explained for beams and slabs.

In most cases, however, T-beams have a greater width of slab as their compression member than is necessary, and then the resistance moment depends only on the amount of steel used. In such cases it may be calculated by the very simple formula :—$R = A \times \cdot 88d \times f$

where $R$ = resistance moment
$A$ = area of steel
$d$ = depth of steel
$f$ = safe stress,

from which clearly it is easy to calculate $R$ when $A$, $d$, and $f$ are known, or to calculate the area of steel required to give a required $R$.

47. To make sure that the compression slab is really strong enough, all that is necessary is to see that the percentage of steel, calculated on the *whole* area $B \times d$, does not exceed ·675 per cent. If it does, the safe strength must be proportionately reduced.

The above really assumes that the neutral axis does not lie *below* the bottom of the slab, since, if it does, it means we have cut away with the shaded areas in *Fig.* 7 not only the concrete which was unstressed, but also part of that which was useful. To check this, see if the thickness of slab is equal to or greater than $\cdot 36\ d$; if not, either the percentage of steel must be somewhat less than ·675 per cent., or the safe strength must be reduced.

48. The question arises, What limits the width $B$ of the T-beam ? This should be limited to—

(*a*) the distance between beams,
(*b*) one-third the span,

whichever is the less. The L.C.C. give other rules of greater complication, and more onerous.

To ensure that the slab will act with the beams, it is necessary that there shall be bars in the slab across the beam. These naturally exist when the slab spans from beam to beam, but if the beam happens to be a main beam (carrying secondary beams and not slabs) such steel may not naturally be provided, but yet it is advisable. As a rule, ⅜-in. rods at 6-in. centres for the width $B$ will be suitable.

49. So far, it is not clear what limits the width of rib $b$ (*Fig.* 7). This is really limited by three considerations :—

(*a*) It must not be less than one-third of the depth, or the concrete cannot readily be poured, and the steel fixed truly in position. This hardly applies to exceptionally large beams.

(*b*) The *shear stress* must not be too great. This will be explained later, but in the meantime the width from this consideration should not be less than $\frac{W}{200\ d}$

where $W$ is load on beam in pounds,
$d$ = depth in inches,

and, even then, *shear reinforcement* is required.

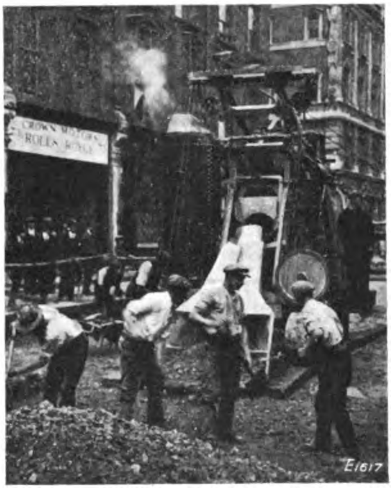
(*c*) If the beam is a continuous one, it has to resist negative bending over the supports (see *Fig.* 6, bottom diagram). This negative moment is about equal to the positive moment near midspan, but while at midspan the slab acts as a compression member, at the support the bottom and not the top is in compression, and therefore at the support the slab does not help.

Hence, the beam will be too weak in compression at the support, if $b$ is made too much less than $B$. This effect can be, and often is, overcome by increasing the depth of the beam near the support, and then keeping it thin, and leads to arched beams, or beams with haunches to the columns. Even so, it will be found that the negative moment often determines the minimum width.

50. The following table gives a series of the author's standard T-beams, and some of their properties, which save a great deal of calculation :—

| Name | Over-all Depth. | Width of Rib. | Tension Steel. | | | Radius Arm. | Section Modu-lus in Steel Units. | Safe Resistance Moment. | Width of Slab needed. *B* | Thick-ness of Slab needed.* | Effective Depth. *d* | Moments of Inertia. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bot-tom Layer. | Top Layer. | Total Area. | | | | | | | Steel Units. | Concrete Units. |
| | in. | in. | | | in.$^2$ | in. | in.$^3$ | in. lb. | in. | in. | in. | in.$^4$ | in.$^4$ |
| 12 × 6 | 12 | 6 | 2—⅝ | 2—⅝ | 1·2 | 9·5 | 11·4 | 185,000 | 10·7 | 3·88 | 10¾ | 78·8 | 1,180 |
| 14 × 6 | 14 | 6 | 2—⅝ | 2—¾ | 1·48 | 11·1 | 16·4 | 256,000 | 14·9 | 4·55 | 15⅝ | 133 | 2,000 |
| 16 × 6 | 16 | 6 | 2—¾ | 2—¾ | 1·76 | 12·8 | 22·5 | 360,000 | 18 | 5·22 | 14½ | 219 | 3,290 |
| 18 × 8 | 18 | 8 | 3—¾ | 3—¾ | 2·64 | 14·5 | 38·2 | 611,000 | 23·7 | 5·95 | 16½ | 405 | 6,090 |
| 20 × 8 | 20 | 8 | 3—¾ | 3—1″ | 3·67 | 16·0 | 58·6 | 940,000 | 29·5 | 6·57 | 18¼ | 687 | 10,300 |
| 22 × 8 | 22 | 8 | 3—1″ | 3—1″ | 4·7 | 17·6 | 83 | 1,330,000 | 34·9 | 7·2 | 20 | 1,065 | 16,000 |
| 24 × 10 | 24 | 10 | 4—1″ | 4—1″ | 6·28 | 19·3 | 121 | 1,940,000 | 42·3 | 7·9 | 22 | 1,710 | 25,600 |
| 26 × 10 | 26 | 10 | 4—1″ | 4—1¼″ | 8·02 | 20·9 | 168 | 2,690,000 | 50 | 8·5 | 23¾ | 2,550 | 38,300 |
| 28 × 10 | 28 | 10 | 4—1¼ | 4—1¼ | 9·76 | 22·4 | 219 | 3,500,000 | 56·6 | 9·2 | 25½ | 3,570 | 53,600 |
| 30 × 12 | 30 | 12 | 5—1¼ | 5—1¼ | 12·2 | 24·2 | 295 | 4,720,000 | 66 | 9·9 | 27½ | 5,200 | 78,000 |

* Where this is not provided, the width of slab must be greater than given in the previous column.



The Milwaukee Paver. Filling the Skip.

# ECONOMY IN CONCRETE ROAD CONSTRUCTION.

An important factor in reducing the initial cost of a concrete road is the extent to which the material of the original road can be utilised as aggregate. Two striking examples of the economy which may be effected by the use of suitable machinery for this purpose have recently come under our notice.

Reference has already been made in the columns of Concrete and Constructional Engineering to the concrete roads in the metropolitan borough of Southwark. Some twelve months ago the Council, on the recommendation of its borough engineer, Mr. Arthur Harrison, purchased a machine for washing and grading the stone from the original macadam roads with a view to its use as aggregate for the concrete roads which were then being laid down. After being washed the material is passed through the grading screen and is delivered in two piles, one containing coarse aggregate and the other fine material from ¼ in. downwards, all ready for use.

In pre-war times all this was regarded as refuse and the Council actually paid to have it removed. Now, not only is this money saved, but, instead of having to purchase aggregate, here an excellent material, washed and graded, is ready to hand for the concrete road.

Although this machine has only been in use a year it has saved thousands of pounds in material, thereby paying for itself over and over again, and the sum thus released has been available for an extension in the employment of labour.

The other example was the use of the Milwaukee Paver, supplied by the Allied Machinery Co., of 132, Queen Victoria Street. This was being operated in Great Portland Street, the whole roadway of which is being reconstructed as a wood block pavement on a concrete foundation.

The machine is self-contained and provides its own power both for locomotion and the operation of the mechanism for mixing and depositing the concrete.

At the back is a skip fixed to the end of an arm, the other end being hinged to the machine. This skip, whose capacity is half a cubic yard, is filled by hand with the dry materials duly proportioned, and is then swung up until the contents fall by gravity along a chute into a mixing drum, the correct amount of water being supplied automatically from a small tank above. After being mixed, the wet material is discharged into a bucket so designed as to open at the bottom. The bucket is then run along an 18 ft. boom which may be swung from side to side, so that the concrete may be deposited at any desired spot in the road.

The total time occupied from the first shovelful being filled into the skip to the final placing of the concrete in position is two minutes, made up as follows :—One minute to fill and hoist the skip, half a minute for mixing and half a minute for discharging, running the bucket along the boom and emptying. Thus practically no time is lost, since directly the skip has poured its contents into the drum it descends and is refilled while the batch is being mixed.

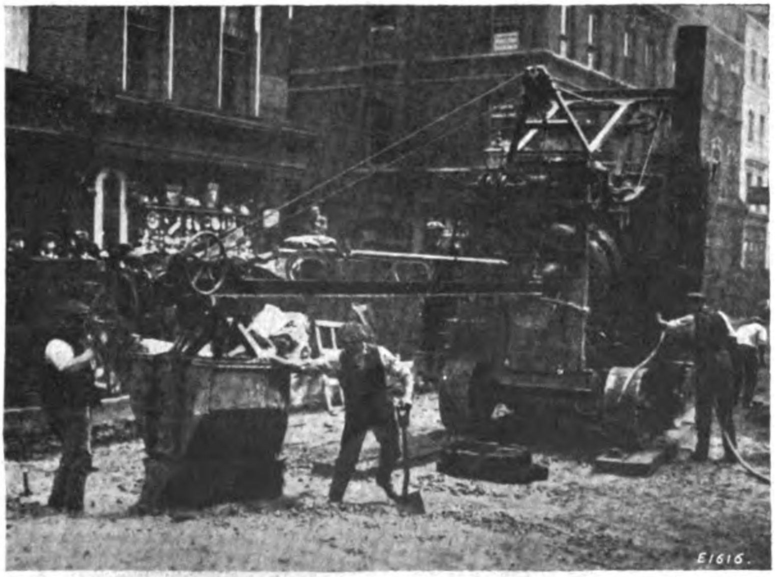
The wet material as it issues from the machine is of a creamy consistency, and, as far as one could judge, exceedingly well mixed.

The essential feature of the Milwaukee Paver is its value as a time-saver, which is so obvious that it calls for no further comment.

Mr. J. Paget Waddington, the Marylebone Borough engineer, to whose courtesy we are indebted for this information, estimates that the whole cost of the machine will probably be saved on this one street alone.

The aggregate for this work consists of the best part of the concrete which formed the base of the original road, and sand, together with new river ballast. As the old concrete is excavated it is selected and the cement portion carted away to a side street where it is passed through a crusher and then returned to the site.

Thus, in the method adopted by Mr. Waddington, there is a double saving—a saving in labour effected by the " paver," and a saving in material by the use of the old concrete as aggregate.



THE MILWAUKEE PAVER. BUCKET DISCHARGING ITS CONTENTS AT THE END OF THE BOOM.

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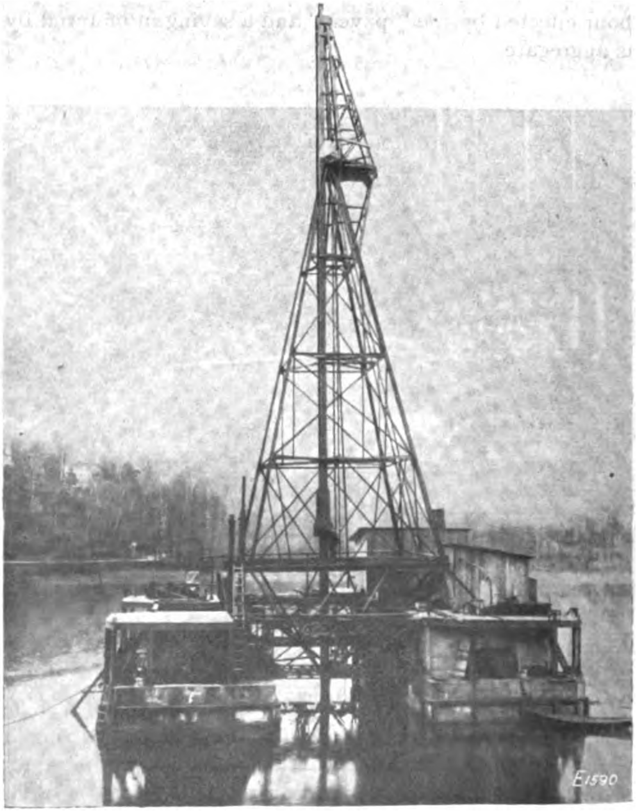
# THE LARGEST PILE-DRIVER IN THE WORLD.

By R. N. STROYER, M.I.M.E.

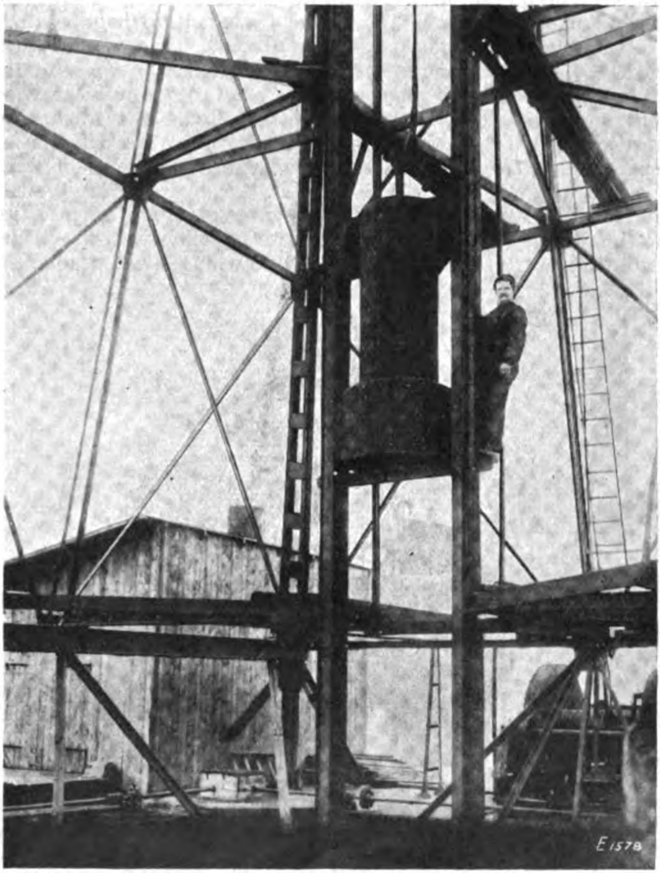
DURING the execution of the foundation work for a large reinforced concrete bridge in Sweden it was found necessary to provide for piles up to 200 ft. in length in order to reach solid bottom, the circumstances being such as to prevent the driving of shorter piles with subsequent building-up and re-driving.

The bridge, which is 3,000 ft. long and connects Ropsten and Lidingö, is constructed with a number of 50 ft. spans, each of which is supported on piles varying



SIDE VIEW OF PILE-DRIVER ON CAISSONS.

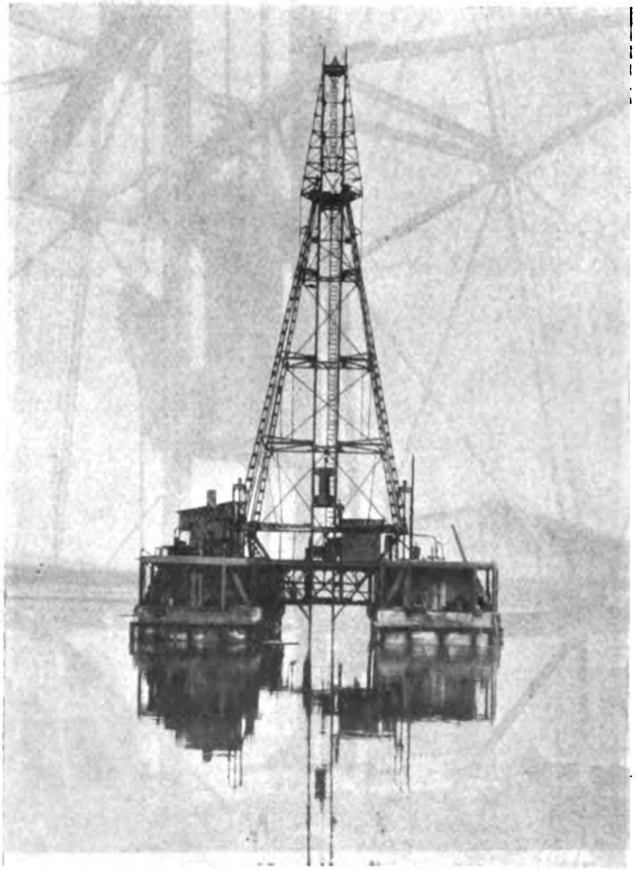
in length from 75 ft. to 200 ft. The depth of water is about 60 ft. and the bottom consists of soft soil for a distance of about 80 ft. down, after which firm ground is encountered. A considerable part of the pile is thus unsupported, which necessitated ample dimensions to prevent buckling. Moreover, as the whole of the driving operations had to be carried out from the surface of the water, the designers were faced with the difficulty of providing a pile 200 ft. long which was of sufficient stiffness to be handled and driven, and which would yet allow of easy transport to a floating pile-driver. The problem was solved by constructing the piles as circular tubes between 3 ft. and 4 ft. diameter reinforced concrete and built in a specially constructed dry dock from which they could be floated out to the pile-driver and filled with concrete after driving.



View of Ram.

The pile-driver, which, of course, had to be specially designed for the purpose, is mounted on four floating caissons built of reinforced concrete. The equipment, which is illustrated on page 570, is provided with pumping machinery for trimming during the handling and pitching of the piles. This trimming arrangement was also utilised to tilt the pile frame in order to drive the piles to a certain inclination, as required by the designers. In addition to the trimming pumps, force pumps were provided for actual driving purposes, two water jets being carried along the whole length of the piles diametrically opposite one another. Hydraulic hose, specially armoured to support the weight due to the considerable length of hose filled with water, was obtained from Messrs. Reddaway and Co. for this purpose.

On account of the height of the pile-driver, special precautions had to be taken against wind pressure, and, as will be noticed, a very broad base is provided so as to minimise the effects of wind tilting. The leaders are of the sliding type and admit of being lowered below water to a considerable depth, while guide rollers are fitted so as to keep the circular piles in place during the driving. The size of the hammer may be judged from the illustration on page 571. The weight of it is about 10 tons.



FRONT VIEW OF PILE-DRIVER.

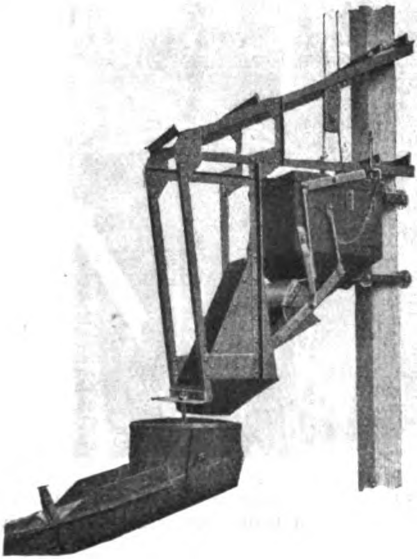
The whole of the pile frame was designed and built by Messrs. Christiani and Nielsen, 25, Victoria Street, Westminster, London, S.W., in connection with the design and execution of the reinforced concrete work mentioned above, for which they were responsible.

# GRAVITY DISTRIBUTING PLANT FOR CONCRETE WORK.

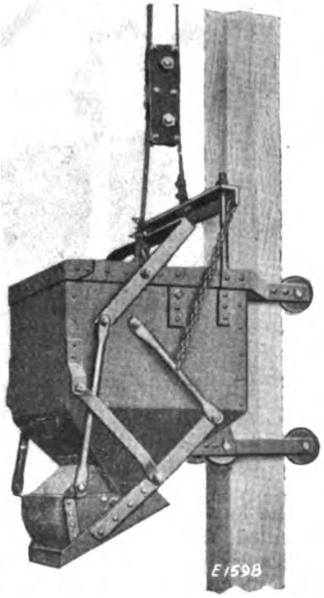
Whatever the ill-effects of the present high cost of all kinds of commodities, among which building construction is as largely affected as any, it is having a beneficial effect in opening the eyes of manufacturers and employers to the absolute necessity for the introduction of time-saving machinery at every possible opportunity, High and ever-increasing wages have, in fact, brought us to the same position in which America found herself before the war, and in that country the solution was found in the application of machinery to mechanical operations from the simplest to the most complex.

In the building industry the cost of materials, has rendered building almost prohibitive except for the most wealthy or for urgent industrial building works where the outlay can be recouped by increased profits. This stoppage of building in itself is a factor in further increasing the amount of tenders, as the same overhead charges have to be met and allowed for in the margin of profit, although it is spread over fewer contracts. It is, therefore, satisfactory to note the increasing use of machinery in the industry. On anything except the smallest job concrete mixers are being more and more extensively used, with the result that not only cheaper but better concrete is obtained; mechanical trench-diggers, steam shovels, and mechanical haulage are also coming more into general use.

A costly item in concrete construction is the time lost in transporting the concrete from the mixing point to the forms where it is required, and on buildings of any size an economy can be effected by the use of a gravity distributing plant. No only does such a plant save time and labour, but, owing to the fact that the concrete is distributed and placed in the forms as soon as it is mixed, a sound construction is practically ensured. Care is, of course, necessary to avoid the use of too wet a mixture, which, although it may travel more quickly through the chute, will not give the strongest concrete; but with a good foreman or superintendent this possibility would not arise. In fact, with the usual slope of 1 in 3 it is concrete of the right consistency which will travel most easily.

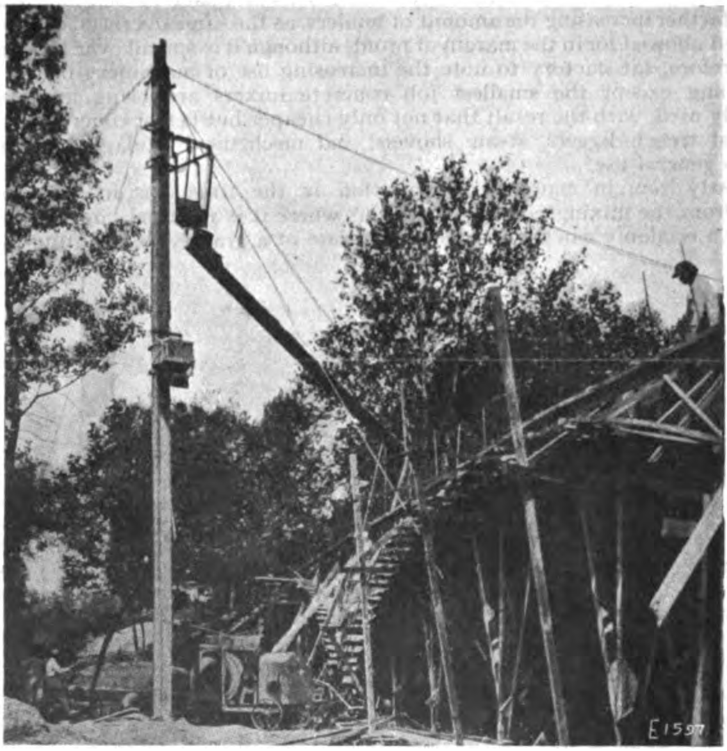


Bucket in Dumping Position.



Bucket Ready to Hoist.

As apart from plant for very large contracts, a hoist bucket and gravity distributing plant has been brought to our notice which appears to be very suitable for smaller work, such as poured concrete housing schemes. This plant (which is manufactured by the Insley Manufacturing Co., of Indianapolis, U.S.A., and for which Messrs. Gaston, Ltd., of 20, Bishopsgate, E.C.2, are the sole importers into this country) is of very simple construction. The mast and chutes are of timber. The strongly made bucket, which has a capacity of 7 cubic feet, is attached to the mast by a frame built out from the back and carrying guide wheels which run in grooves in the timber. After being filled and hoisted to the top the load is automatically discharged into the mouth of the chute by the action of a lever on the frame at the head of the mast. This frame also contains a small hopper which guides the concrete into the chute; it can be moved to any position on the mast to suit the height of the work in progress, or, if required, it can be fixed low enough to discharge the loads into carts or trucks.



After the load has been dumped from the bucket the gate is automatically closed. When filled, the bucket weighs about 1,300 lb., and a motor or engine of between 6 and 8 horse-power is required for its operation.

The cheapest permanent houses now being built under the Government housing scheme are of concrete, the saving resulting mainly from the smaller amount of skilled labour required owing to the fewer component parts to be handled as compared with brick construction, and it is obvious that the more labour-saving machinery that can be introduced into the work the cheaper the construction will be. A further consideration to be taken into account is that with the use of a distributing plant such as that described above the form work can be considerably simplified, as the trestles and runways which are necessary when the concrete is wheeled by hand may be omitted. This plant is specially constructed for small work, and, as it can be rapidly dismantled and erected on another job, should quickly repay for the initial outlay. We recommend any of our readers who may be interested to apply to Messrs. Gaston for a catalogue of their gravity plant of various sizes.

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# NEW BOOKS

## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

### "The Studio" Year Book of Decorative Art, 1920.

(Published at the Office of "The Studio," 7/6 net.)

The 1920 edition of this Year Book gives some excellent illustrations and information as to what is being done in decorative and applied art. There are some examples of the older types of houses and farm buildings in the various English counties, together with examples of similar work in Holland and France.

In an article entitled "Concrete Homes," Mr. Maurice S. R. Adams, A.R.I.B.A., deals very fully with the possibilities of concrete for house and cottage building.

In a recent issue of this journal we dealt very fully with Mr. Adams' special system of Arch construction, and it is not necessary, therefore, to describe it here. In the article under review he gives various elevations and plans for houses on this system, and in view of the prejudice which still widely exists regarding concrete we would quote the following paragraph from his article :—

"On the practical side certain questions are frequently asked, such, for instance, as whether concrete houses are damp ; whether they 'sweat' ; how they are finished ; whether they are cold to live in ; and what the floors are covered with. The reason why some concrete houses have been found to be damp is due to the nature of the concrete used. Concrete may be made very dense, or compact and very hard ; or it may be made porous and open in texture. Any non-absorbent material will 'sweat' through condensation of water from the atmosphere. This will occur on painted plaster, whether over brickwork or concrete. For house construction only porous materials which breathe freely should be used. Porous concrete, when properly made, is superior to brickwork, for it is neither damp nor does it sweat."

The article contains many useful suggestions for the interior treatment and decoration of concrete houses.

### "Stresses in Hooks and Other Curved Beams." By E. S. Andrews.

This little book is chiefly a mathematical treatment of bent beams, which gives an excellent theoretical account of the whole subject. It is not one which an engineer who is afraid of fairly advanced mathematics would read readily, but it is done so thoroughly that it will probably be considered to be the standard work on the subject for many years to come.

The results are rendered of practical utility to the non-mathematical engineer by the calculation of the corrections of coefficients, whereby the stresses at the inside and outside of curved beams can be calculated by the ordinary formulæ for straight beams and then corrected by applying a suitable coefficient from Mr. Andrews's corrections, which are given for rectangle, circle, and triangle, and the special corrections which apply to coupling hooks and crane hooks.

It would have been easier to follow if a list of symbols had been given.

It is not stated that the correction coefficients for the triangle only apply when the flat portion is on the inside of the bend, and the pointed portion on the outside though this is, of course, the case.

The theoretical results are then compared with the experimental results obtained on various published tests, all of which were based on the measured maximum pull of the hook when the elastic limit is reached, and the agreement is so good as to leave nothing to be desired for any practical purpose whatever.

The whole work is of a very high order and, for anyone interested in the subject, to be thoroughly recommended.

# THE FOREIGN PRESS.

*The following are abstracts taken from the foreign Press relating to concrete construction.—ED.*

**Concrete Ashlar.**—Concrete blocks as a substitute for ashlar are rapidly gaining in popularity, and although some architects pretend that concrete is useless for beautiful exteriors, and that much of the modern concrete is far from durable, actual experience has shown that neither of these statements is wholly true. Some undoubtedly beautiful structures have been built of concrete blocks moulded to represent ashlar, and these have been found to be fully as durable as many pieces of worked stone.

By carting the raw materials to the site, the cost of transport is much less than for worked stone (which must be more carefully handled), and if a fairly rapid-setting cement of good quality is used, the number of moulds required can be reduced to a minimum. A small gang of men can rapidly mould all the blocks required—even the most complex—and they are then ready to be placed in position.

Monotony of design is easily avoided when a sufficiently large number of dwellings are required, and in many cases, at the present time, the need for rapid construction is so great that æsthetic considerations are relegated to the background.

A pillar and panel type of structure lends itself best to rapid construction, and if the blocks used have an average volume of 960-1,280 c. in., so that about 40 blocks form a cubic yard, they will be handled so conveniently that even if they cost more to produce than worked stone, they save the cost of delivery and gain in rapidity of laying. —*Revue des Matériaux de Constructions.*

**The Proportion of Water Required when Gauging Concrete.**—There is no simple means for determining the proportion of water which should be added to a given concrete aggregate and cement in order to produce a mixture of suitable consistency, as so many factors enter into the matter. L. Guillemet has, however, found that the following formula is usually applicable :

$$W=\frac{C}{50}+25-(S+2G)$$

where

$W$=quantity of water required in gallons.

$C$=weight of cement (in lbs.) for 100 gallons of sand and 20 gallons of gravel.

$S$=volume of water (in gallons) in 100 gallons of sand.

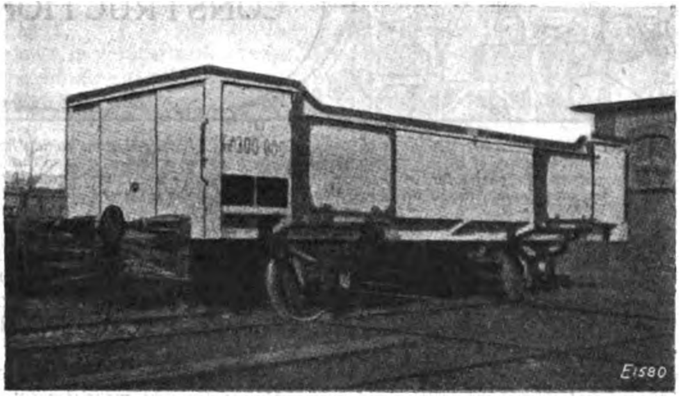
$G$=volume of water (in gallons) in 100 gallons of gravel.

On the whole, it is better in reinforced concrete to use rather too much water than too little, but for mass concrete it is better to use rather too little water.—*Béton Armé.*

**Testing Concrete Trucks.**—A recent official test of an Austrian railway truck built of concrete throws an interesting light on the strength of this new application of reinforced concrete.

The truck, of 30 tons nominal capacity, filled with wet rock weighing 31·6 tons, was hauled at the normal speed, first alone and afterwards as the first of a train of 15 loaded trucks ; it was stopped suddenly by applying the brakes. It was afterwards hauled coupled in front of 15 other trucks and was pushed at more than normal speed until it collided with a stationary train, but without much harm, though the shock was so great that the stationary train was seriously damaged. The actual defects revealed on minute inspection were : (1) a previously existing crack was slightly enlarged, (2) a new crack was found on the front of the car, (3) a little spalling had occurred on the front, (4) two cracks at the corners between the end and side, (5) a crack at the crank pin above the side door, and (6) various hair cracks in the beam under the bearing.

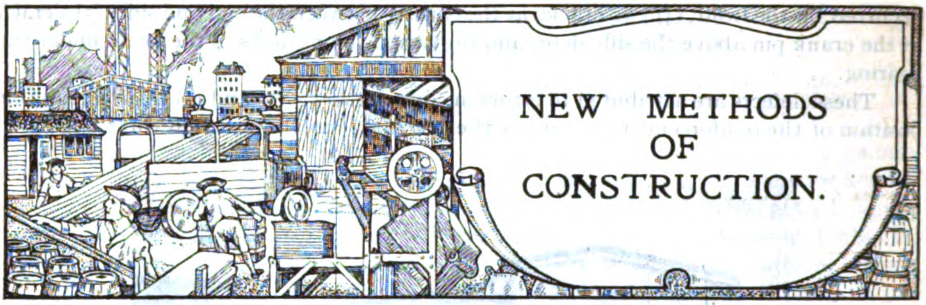
These defects are attributed to errors in construction: (1) and (2) to an unsuitable position of the reinforcement in front of the truck, (3) to the use of Rabitz expanded metal, (4) to the corners not being sufficiently rounded, and (5) to a weak place in the structure which can easily be remedied in future trucks. The slight hair cracks are of no importance. As none of the defects are serious, the truck is to be repaired and put into use.



The results of the test have so far exceeded expectations that a number of German and Austrian firms are interesting themselves in the subject and propose to build similar trucks of reinforced concrete.—*Beton u. Eisen.*

**L-Rails and Concrete Structures.**—The results of a series of tests by Prof. Kleinlogel, of Darmstadt, have shown that L-rails may be used with advantage with reinforcement for concrete, for the following reasons:

1. The L-rail can be completely covered with concrete and thus rendered rust-proof and fire-resisting.
2. The adhesion of the concrete to such rails is very good, no hooks or cross pieces being necessary.
3. Shearing trusses are usually taken by iron rods associated with the L-rails.
4. The L-shape presents a profile of advantageous form.
5. The cross-section of an L-rail is well adapted for suspended loads, especially power cables, shafting, etc., and for the safe distribution of members of reinforced concrete, and the use of such rails appears to solve a very serious problem in a simple and satisfactory manner.
6. About 1,200 tons of L-rails have been in use as reinforcement for some time, and no complaints have been received.



# NEW METHODS OF CONSTRUCTION.

*In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—ED.*

## "ECONOMIC" FLOORS AND ROOFS (PATENT).

REINFORCED CONCRETE has been put to so many uses it would, indeed, be hard to find a branch of building work to which it has not been adapted; inventive genius, therefore, nowadays, concentrates chiefly on improving the methods of applying this form of construction.

A review of the latest patent processes emphasises the fact that efforts are made, primarily, with a view to assuring cheapness without loss of rigidity or strength of the finished work, and that the greatest success has been attained where the carrying out of the work is as simple as possible and where the more expensive items, which in the past have militated so largely against the employment of reinforced concrete, have been wholly or partially eliminated.

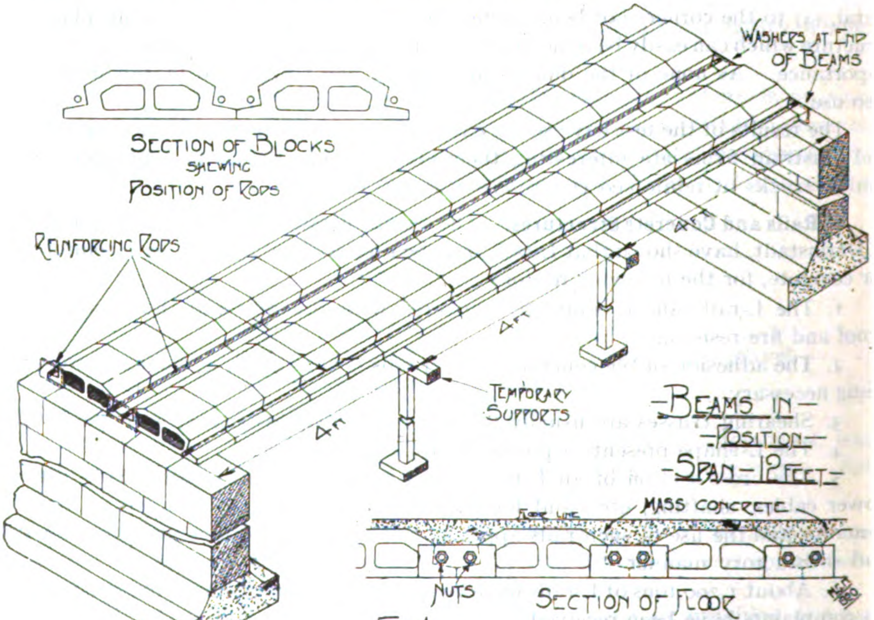


FIG 1

In the "Economic" patent system here described the inventor claims to have made an advance along scientific lines. In the construction of floors and roofs, tackle and the handling of any weight greater than 50 to 60 lb. are avoided, shuttering is eliminated, and, with properly embedded steel rods, the finished work is stated to give a reliable hollow, fire-resisting and sound-proof floor or roof, with ceiling complete, at a very low cost.

To render shuttering unnecessary the area to be floored is covered by a series of self-supporting beams composed of hollow concrete or breeze blocks assembled on planking, *in situ* over temporary supports, and held together by an arrangement of bolts and washers at the ends of rods, which in the finished floor act as the tensional members, *Fig.* 1.

The process is very simple, beam after beam being laid and bolted up, the planks on which the blocks have been assembled are withdrawn leaving a self-supporting area over which mass concrete is spread to the required thickness.

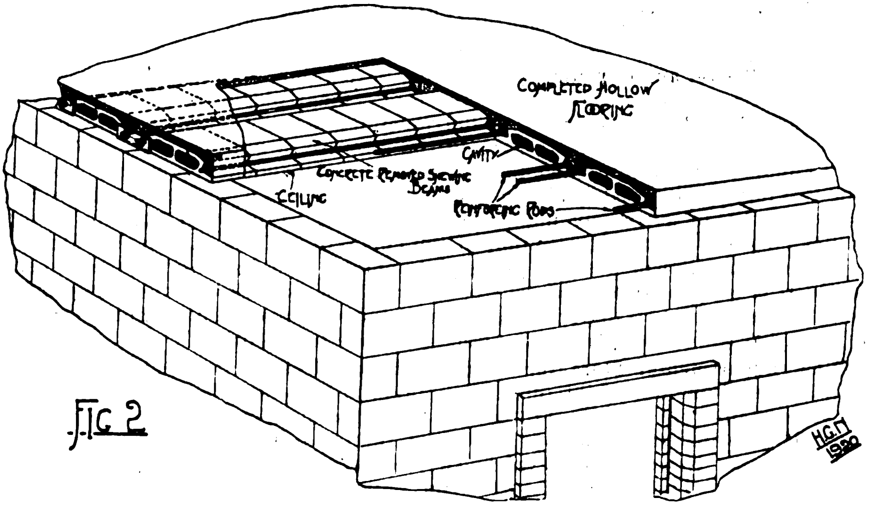
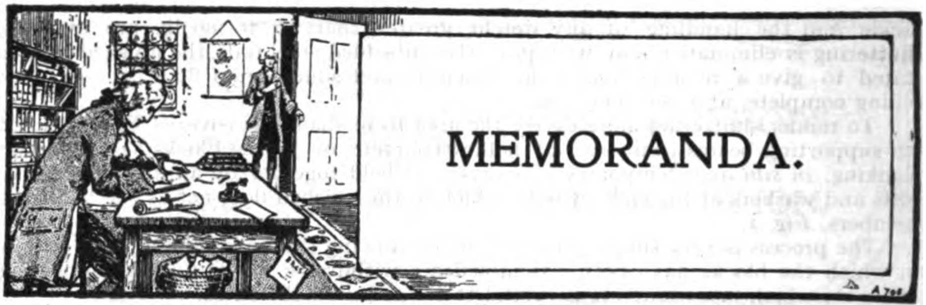


FIG 2

The beams referred to above, spanning from wall to wall, over temporary intermediate props, are stated to be sufficiently rigid to support the load brought to bear in placing the mass concrete, and, the latter having set, the removal of the intermediates completes the work. (*Fig.* 2 shows general details of construction.)

This system was shown at the recent "Ideal Homes" and "Building Trades" Exhibitions, and has already been adopted on housing schemes in various parts of this country; designs are also in hand for the flooring of several factories carrying loads up to 5 cwt. per super foot.

The patent is in the hands of Mr. Geo. C. Thompson, 609–611, Ulster Chambers, 168, Regent Street, London, W.1 (Government and Public Works contractor), from whom further particulars can be obtained.



*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Cement Plaster and Gypsum.**—The United States Bureau of Standards has recently conducted investigations into the adherence of cement plaster to gypsum, and in its report states that there seems to be no detrimental reaction between the two materials. It was found that the tensile strength of the mixture of gypsum and cement is very nearly equal to their combined tensile strengths, dependent upon the proportions of the two ingredients used. The suction of the surface to which the plaster is applied is stated to be an extremely important factor; for example, if gypsum is applied to a dry concrete surface the suction of the concrete will take so much water out of the gypsum that it will prevent proper hardening. The expansion of neat cement, when wet, is of an entirely different order from the expansion of neat gypsum, and a bond between the two materials can be permanently maintained only when enough sand is added to both materials to reduce the same from both.

**New Departmental Store for Leeds.**—Having decided to erect new buildings, Messrs. Marsh Jones and Cribb offered a number of premiums for competition designs. Thirty-one plans were submitted by several leading architects, including a few American firms. The award was in favour of Messrs. James T. Cackett and R. Burns Dick, F.F.R.I.B.A., of Newcastle-on-Tyne. The construction is to be steel frame and reinforced concrete. The estimated cost of the building is put at £300,000.

**A Large Stadium in U.S.A.**—The erection of a very large U-shaped concrete and steel stadium has just been commenced in America. It is being built on the University of Washington campus, at the edge of Lake Washington. The total cost is estimated at about $600,000, and the stadium will seat 60,000 persons. The height of the structure will be 72 ft. from sea level and there will be two great towers surmounting the main entrance at the bow of the U. The width from the exterior walls, including the field, will be 630 ft., and the length from the open end to the great towers will be 665 ft. A 25-ft. colonnade covered with wide arches overlooking the field will flank the entire structure. The cantilever overhang will provide for an extra seating capacity of 13,000 persons. The seats will be constructed around a ¼-mile running track with a 220-yd. straightway. The field, which will be 300 ft. by 470 ft., will be large enough to hold football, baseball, track and other athletic contests, as well as games, festivals, etc.

**Concrete Logs.**—The manager of a United States concrete manufacturing company has conceived the idea of building houses with concrete logs. The logs are made in metal moulds, adjustable as to length also, so as to cast small units of the usual block sizes. He has just built a house with such logs containing five rooms, at a cost of 2,800 dollars.

**Cemented Fagots for dealing with a Pit-shaft Subsidence.**—The *Technical Review* gives an abstract from two French periodicals in which an article on this subject appeared. The article describes the repairs to a French pit-shaft which had subsided:

"The subsidence was overcome by throwing fagots into the mine, afterwards suitably anchoring them. The whole was consolidated by grouting, which was forced in by compressed air, the pipes used being 64 mm. diameter. The grout used was fairly thin (1 part cement to 4 of water), so as to penetrate thoroughly. A little sand was added to the mixture to increase the binding properties. The grouting took five months to complete (as the work had to be interrupted several times), and 1,000 tons cement and 68 cbm. sand were used. The result was very satisfactory, the fagots and the grouting forming a very hard block which adhered well to the ground.

"The pit was re-started by means of a concrete ring 8 metres diameter, and 1·2 metres high, placed concentrically to the axis of the pit at a distance of 250 m. This concrete ring (300 kg. of hydraulic lime per cbm. of rubble and river sand) was constructed in successive segments. Upon this base, three concrete rings 1·50 m. high, 4 m. internal diameter, and 7 m. external diameter, were placed, the last ring of the series connecting with the base of the grouted fagot monolith. The pit-shaft was opened up by blasting a hole in the grouted monolith, this operation proceeding upwards. The hole was then enlarged by working downwards until it had attained the proper diameter. The whole of the section of the shaft repaired was lined with arched masonry of cement concrete."

**Scientific and Industrial Research.**—Professor Sir John Cadman, K.C.M.G., D.Sc., University of Birmingham, Mr. W. B. Hardy, Soc.R.S., Gonville and Caius College, Cambridge, and Professor Sydney Young, D.Sc., F.R.S., Trinity College, Dublin, have been appointed by an Order of Council dated June 24th, 1920, to be members of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

The Lord President, as President of the Committee of Council for Scientific and Industrial Research, has appointed Dr. J. S. Flett, F.R.S., at present Assistant to the Director in Scotland, to be Director of the Geological Survey and Museum, in place of Sir Aubrey Strahan, K.B.E., F.R.S., who has retired.

**British Engineering Standards Association (Incorporated 1918).**—The British Engineering Standards Association held its second annual meeting on Thursday, July 15th, at the Institution of Civil Engineers, when the Chairman, Sir Archibald Denny, Bart., presented the report and made a review of the position, dwelling with especial emphasis on the need for further financial support.

Last year the Chairman showed the vast increase in work of this national organisation both at home and abroad, and this year he was again able to chronicle further progress. The Association is rendering an indispensable service to British trade at home in co-ordinating standards, promoting efficiency and eliminating waste, and is also doing much to push British trade abroad. It is therefore regrettable that even after twenty years of useful work the engineering industry of the country is only now slowly putting the Association in a position adequately to cope with the increasing demands made upon its organisation.

There are some 300 committees manned by over 1,400 members, who, as the Chairman pointed out, give their time and experience, often at great personal expense and inconvenience, to this great national work, and the country as a whole as well as the industry owes a deep debt of gratitude to these public-spirited gentlemen for their loyal service, and also to the engineering firms who allow their engineers, managers and others to take part in the work.

The national importance of this Association in the development of trade both at home and abroad is being more and more appreciated, and the increased demands being made on it by the industry augurs well for its future.

The Chairman mentioned that since the last annual meeting 27 British Standard Specifications had been issued and some 70 are under revision, the most important of which, the steel sections for general building construction, including shipbuilding, have just been completed.

Regarding the new work which the Association has in hand, this includes the drafting of British Standard Specifications for various chemical products, copper alloys, materials and constructional strength of chemical fire extinguishers, steel wire ropes, steel bridge construction, and milling cutters and reamers, this latter report being one of the most comprehensive issued during the year.

It is interesting to see that the engineering public is making increased use of the British Standard Specifications, for the Chairman stated that 31,000 of the specifications had been sold almost all in this country, against about 3,000 in pre-war years.

**British Honduras.**—The new Director of Public Works of British Honduras, Mr. M. A. Murphy, is contemplating an extensive programme of construction in that colony.

Several hundred miles of road must be constructed as expeditiously as possible to permit the employment of efficient motor transport and to open the large areas needed for the Government's extensive agricultural programme. The improvement of the harbour of Belize must be undertaken again and completed. This involves the removal of the river bar, the walling of the area reclaimed by the spoil from the sea, the placing of new bridges across the river, the construction of a centralised group of customs buildings at the river mouth, and the provision of a wharf with suitable machinery for handling freight with despatch and economy. The piers at several settlements must be rebuilt. It is likely that both water and sewerage systems must be installed at Belize before long, an undertaking rendered difficult by the low level of the town. There are many other problems.

It is proposed that all new construction be of permanent materials. Heretofore, timber has been almost exclusively employed. Although some structural metal must now be used, it is probable that concrete construction will be most largely employed. It has special advantages for tropical use.

The Public Works Department will need considerable quantities of reinforcement, cement and steel, as well as much road-making, dredging and other equipment. In view of the difficulty of obtaining expert representation in Belize, it is probable that mail proposals will receive most careful consideration.

**Iron and Steel Institute.**—The autumn meeting of the Institute will be held in Cardiff, at the South Wales Institute of Engineers, from September 21st to 24th.

## TENDERS ACCEPTED.

### Concrete Houses.

BARNSLEY.—For the erection of 100 houses of the "Dorman Long" type, the Barnsley Town Council has accepted the tender, amounting to £89,954 11s. 8d., of Messrs. W. Durks & Son.

CHELMSFORD.—The Unit Construction Co., Ltd., of 168, Regent Street, W., has been awarded a contract by the Town Council for the erection of the following houses :—Twenty pairs type "H1," at £1,894 4s. 9d. per house ; 24 pairs type "K," at £1,894 8s. 1½d. per house ; and 20 pairs type "L," at £1,767 4s. 5d. per house ; total (128 houses), £118,685 18s. 4d.

CHELTENHAM.—Subject to modification, the Cheltenham Town Council has accepted the following tenders for the erection of concrete houses :—A. C. Billings & Sons, Ltd (10 houses on the "Calway" system) ; Collins & Godfrey (10 houses on the "Calway" system) ; W. T. Nicholls, Ltd. (20 houses on the "Winget" system).

EARSDON.—The following tenders have been received by the Earsdon Urban District Council for the erection of houses and bungalows on the "Dorman Long" system, and have been forwarded to the Housing Commissioner for approval :—Mr. G. Carr (parlour type houses), £977 each ; Messrs. Somerville (bungalow type), £807 each.

GLASGOW.—The Greenhead housing scheme of the Glasgow Corporation is to be carried out half in concrete and half in brickwork ; Mr. John Taylor has received the contract, amounting to £76,571 2s. 10d., for excavator and concrete work in connection with the former part of the scheme.

GUISBOROUGH.—Evidently well satisfied with the 98 houses it has already erected on the "Dorman Long" steel frame and concrete system, the Guisborough Rural District Council has now decided on the erection of a further 130 houses on the same method.

LEEDS.—The Town Council has awarded a contract for the erection of 162 concrete houses on the Harehills site of Messrs. Harold Arnold & Sons, as follows :—Type "A" houses, £925 each ; type "B" houses, £1,040 each. The Council has also decided on the erection of two demonstration houses on the "Léan" system on the Meanwood site, and the work is to be carried out by Mr. J. H. Bardsley at a cost of £860 each.

PONTYPOOL.—The Urban District Council has accepted the tender of Messrs. Nicholls, at £70,000 for the erection of seventy houses on the "Dorman Long" system.

SOUTHEND-ON-SEA.—The Simplex Construction Co., Ltd., of Yiewsley, Middlesex, has been awarded a contract by the Southend-on-Sea Town Council for the erection of 100 houses on the Sutton Road site, at a total cost of £97,500, on the following basis prices :—Block of six Class "B" houses, £5,718 10s. ; block of three Class "B" houses, £2,898 ; block of two Class "B" houses, £1,930 ; block of four Class "A" houses, £3,535 10s.

## PUBLICATIONS.

**Hy-Rib.**—A new edition has just been published by the Trussed Concrete Steel Company, Ltd., dealing with Hy-Rib centering and reinforcement. In a brief introduction, Hy-Rib, its uses and the method of its manufacture are dealt with. The booklet is well got up, and contains a large number of interesting illustrations showing the extensive and varied use to which the material has been put. The diagrams and tables will prove useful to engineers and others when designing structures in which they propose using this material as centering or reinforcement.

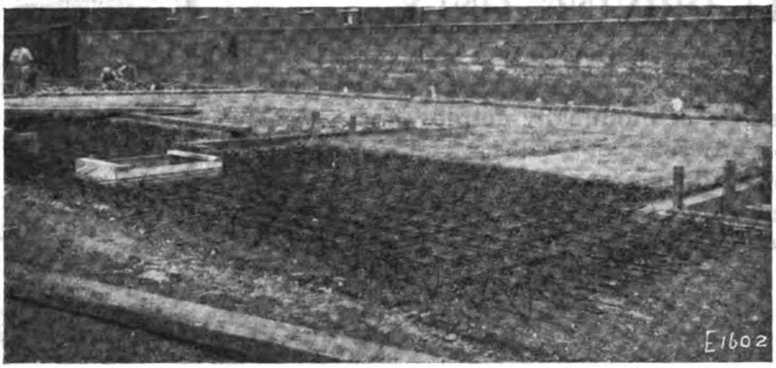
The booklet also gives particulars of a special punch for fastening Hy-rib sheets together and for punching holes when the material is attached to structural steel with plates. A hand-power bender is also illustrated and described.

Copies of the booklet can be obtained from the Trussed Concrete Steel Co., Ltd., 22, Cranley Gardens, South Kensington, S.W.7.

## TRADE NOTES.

**Reinforced Concrete Raft.**—The accompanying illustration shows a segment of the Walker-Weston Patent Pyramidal Reinforcement laid in position ready for concreting, with the remainder of the reinforcement covered with 7 in. of concrete and awaiting the top layer of 2 in. of finer mixture as surfacing.

The reinforcement is laid in suitably-sized segments measuring 22 ft. by 7 ft., with the bars between these units overlapping about 18 in. The thickness of the framework for a 9 in. concrete raft is 5½ in. between top and bottom layers, giving 1½ in. and 2 in. cover at bottom and top respectively. The diagonal shear members and loop bars are 3-16ths in. diameter with 5-16ths in. longitudinal, and transverse bars joining the top and bottom layers. The squares at top and bottom of the framework are 13 in., and additional longitudinal and transverse bars are tied on to the bottom layer of the framework reducing the interstices to 6½ in. by 6½ in. Unit is interlocked with unit longitudinally by coupling adjacent diagonal zig-zag bars to form pyramids common to each unit, which pyramids are locked longitudinally and transversely. The reinforcement is continuous and homogeneous throughout.



The raft constitutes ground-floor of factories being erected at Mortlake by Messrs. Watney, Combe, Reid & Co., Ltd., and the whole of the work is under the supervision of their architect, Mr. M. T. Saunders.

**Messrs. Vickers, Ltd.,** Broadway, London, S.W.1., inform us they have opened a depot for Wales and the South-West of England at 43, Park Street, Bristol, at which address they will be glad to receive enquiries for their products.

**A New Concrete Mixer.**—At the Building Trades Exhibition recently held, Messrs. Millars' Timber Trading Company, Ltd., of Pinner's Hall, London, E.C. 2, exhibited a concrete mixer, known as the Jaeger mixer. A special feature of the machine is the tilting drum, which has two flat spaces on either side to ensure a correct mixing of the material. The flat portions of the drum cause a circling movement of the material, bringing it up from the bottom, and a cone-shaped neck carrying it back through the specially arranged ploughs. The machine is obtainable in different sizes, it is easily moved from place to place, and owing to the simplicity of its mechanism is easily kept clean.

**The "Handy" Concrete Block-making Machine.**—This machine, which has recently been put on the market by Messrs. Armstrong & Bell, of Sheffield, is especially intended for the use of the small builder. It is designed on lines which have been

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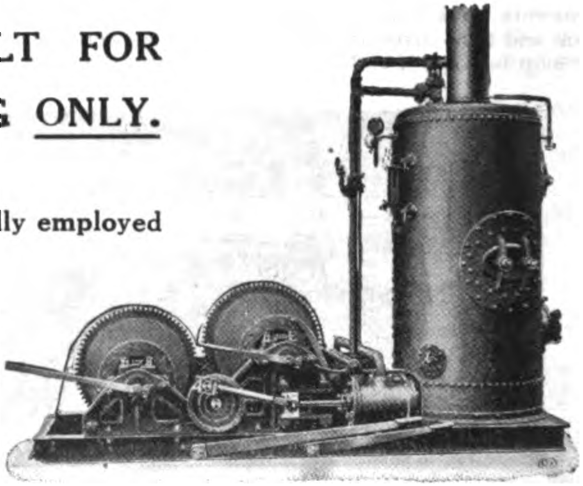

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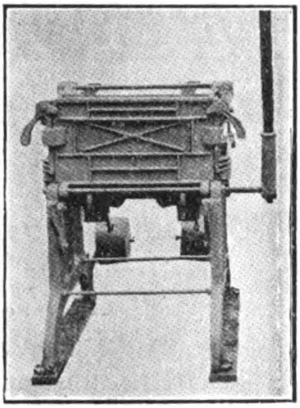
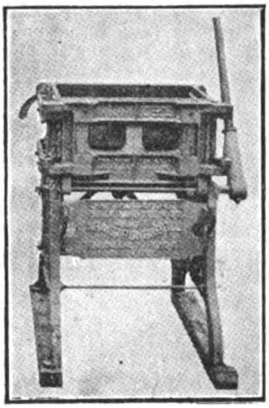


TYPE A.



TYPE B.

Demonstrations with the " Handy " block-making machine are given by Mr. J. H. Armstrong at 190, Worple Road, Wimbledon, S.W.19.

This same firm also makes a concrete brick machine. The bricks are made on the wet process and one man can make 1,500 bricks per day, the concrete being ready mixed for him.

With the use of the " Handy " concrete roofing tile machine interlocking ribbed concrete tiles of any desired colour on surfaces can be produced.

**Concrete Blocks, etc.**—Messrs. Vernon & Sons have sent us some illustrations of their concrete works near Wolverhampton where they are manufacturing and selling concrete blocks, roofing tiles and other concrete products. They have also erected two concrete block houses, which, they state, have been built entirely with unskilled labour.

The blocks manufactured are 16 × 9 × 8 in., the tiles 12 × 8. They also make breeze bricks 16 × 8 × 4. For full particulars of their manufactures apply to Messrs. Vernon & Sons, Langley Sand Beds, and Concrete Works, Lower Penn, Wolverhampton.

**An Ideal Sanitary Dustbin.**—At the Health Exhibition held in Birmingham (July 19th to August 5th), a combined sanitary dustbin and automatic cinder sifter was shown. The actual bin is made of mild steel with rounded corners and then galvanised. The interesting point for our readers is the cinder sifter frame, which the inventor proposes to construct in reinforced concrete on account of its great strength and durability. Other interesting features are a special food waste bin which can be attached outside the main bin on hooks specially provided for same. The inventor is Mr. Geo. M. Pinkerton, 76, Endlesham Road, Balham, S.W.12.

## PERSONAL.

Mr. Arthur G. Tonks has been appointed representative for B.R.C. Roads (British Reinforced Engineering Co., Ltd.) for part of London, and the South Eastern Counties.

## NEW COMPANIES REGISTERED.

Concrete Cottages, Ltd. (168,932).—Registered July 10th, 70, Victoria Street, Westminster. Builders and contractors. Nominal capital, £10,500 in 10,000 £1 cumulative preference shares and 10,000 1s. ordinary shares. Directors : N. S. Beatty, Bush House, Isleworth, and T. Shepherd, The Woodlands, Moseley, Birmingham. Qualification of directors, 50 shares ; remuneration to be voted.

Concrete Dwellings (Belgium), Ltd. (168,658).—Registered June 29th. Constructional engineers, builders and contractors. Nominal capital, £10,000 in 10,000 £1 shares. Directors: C. H. Campbell, 81, Eaton Place, S.W.1 ; C. H. Magnias, Ashtead Park, Surrey ; C. T. McMahon, Foxley Lane, Purley, Surrey ; and C. T. Bazell, Holywell Lodge, Wendover. Qualification of directors, £100 ; remuneration, £100 each (Chairman £150).

Dudley Lewis Inter-Cavity Construction Co., Ltd. (168,501).—Registered June 23rd. Builders and contractors. Nominal capital, £3,000 in 3,000 £1 shares. Directors : C. D. Lewis, G. M. P. Layton and J. S. Davey. Qualification of directors, one share ; remuneration to be voted by company. Subscribers : A. E. Matthews, 86, Brookwood Road, London, S.W.18, and W. T. Garratt, 19, Dollis Road, Finchley, N.W.

Border Engineering Contractors, Ltd. (168,603).—62, Church Road, Harrington, Cumberland. Reinforced concrete and structural engineers. Nominal capital, £3,000, in 3,000 £1 shares. Managing director, · D. Johnston. Qualification of directors, £150 ; remuneration to be voted by company.

## RECENT PATENT APPLICATIONS.

143,598.—J. H. W. de Waller : Reinforced concrete floor construction.

143,601.—W. R. Smith : Walls of hollow slabs.

143,632.—A. Drew : Beams and structures of reinforced concrete.

143,633.—J. A. A. Nystrom : Hollow building blocks and walls.

143,691.—Bell's United Asbestos Co., E. Hurden and J. A. Cann : Building blocks and slabs.

143,694.—H. E. Dakin and H. E. Dakin, Ltd. : Structures and reinforced concrete.

143,698.—J. A. Calvert : Reinforced concrete construction.

143,749.—C. W. Bosher : Building bricks and blocks and moulds for same.

143,956.—A. Dickson : Construction of walls.

144,004.—H. J. Boss and E. M. Richardson : Method of building concrete walls.

144,193.—W Wilson : Reinforced concrete and cement beams.

144,377 and 144,378.—C. P. Lovell : Building blocks.

144,389.—A. J. Dunn : Concrete buildings.

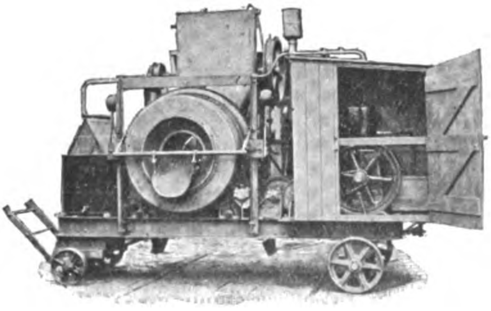
144,394.—H. Addison : Floor construction.

144,414.—B. Fullwood : Concrete buildings.

144,426.—R. Neilson : Reinforced concrete pipes and tubes.

144,480.—H. L. Doulton and C H. Giles : Block-making machines.

144,546.—J. H. Harrison : Moulds of concrete.



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# CONCRETE AND CONSTRUCTIONAL ENGINEERING

THE OFFICIALLY APPOINTED JOURNAL OF THE CONCRETE INSTITUTE

SEPTEMBER 1920. VOL. XV. No. 9.

*A MONTHLY JOURNAL for Engineers, Architects, Surveyors, and Contractors, and all interested in Cement, Concrete, Reinforced Concrete, Fire-Resisting Construction and Structural Steel*

ISSUED MONTHLY

## CONTENTS.

Editorials.

Concrete Cottage Building.
Cottages at Blackpool and Potters Bar.

Reinforced Concrete Retaining Walls Without Buttresses.
By Prof. E. R. MATTHEWS, B.Sc. (Eng.), F.R.S.E., etc.

The Results of American Experience in the Use of Hydrated Lime in Concrete Roads.
By A. E. WYNN, B.Sc., Assoc.M.Am.Soc.C.E.

Some Reinforced Concrete Structures in Australia.
By E. G. STONE.

The Alhambra Theatre, Valparaiso, Chili.
By GEO. MALLETT.

The Economical Design of Reinforced Concrete Foundation Slabs.
By CHARLES S. HIGGINS, B.Sc., A.M.Inst.C.E.

The Use of Concrete in the Netherlands.
By A. E. DINGER.

A Civil Engineer's Impression of America.

A Swedish Concrete Bridge.

Trimstone and Building Ornaments.
By A. SCHILLING.

New Books.

The Foreign Press. The "Hume" Pipe.

Questions and Answers Relating to Concrete. Memoranda.

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Monthly Notes, by the Secretary.
Concrete Aggregates. Southwark Bridge Reconstruction.

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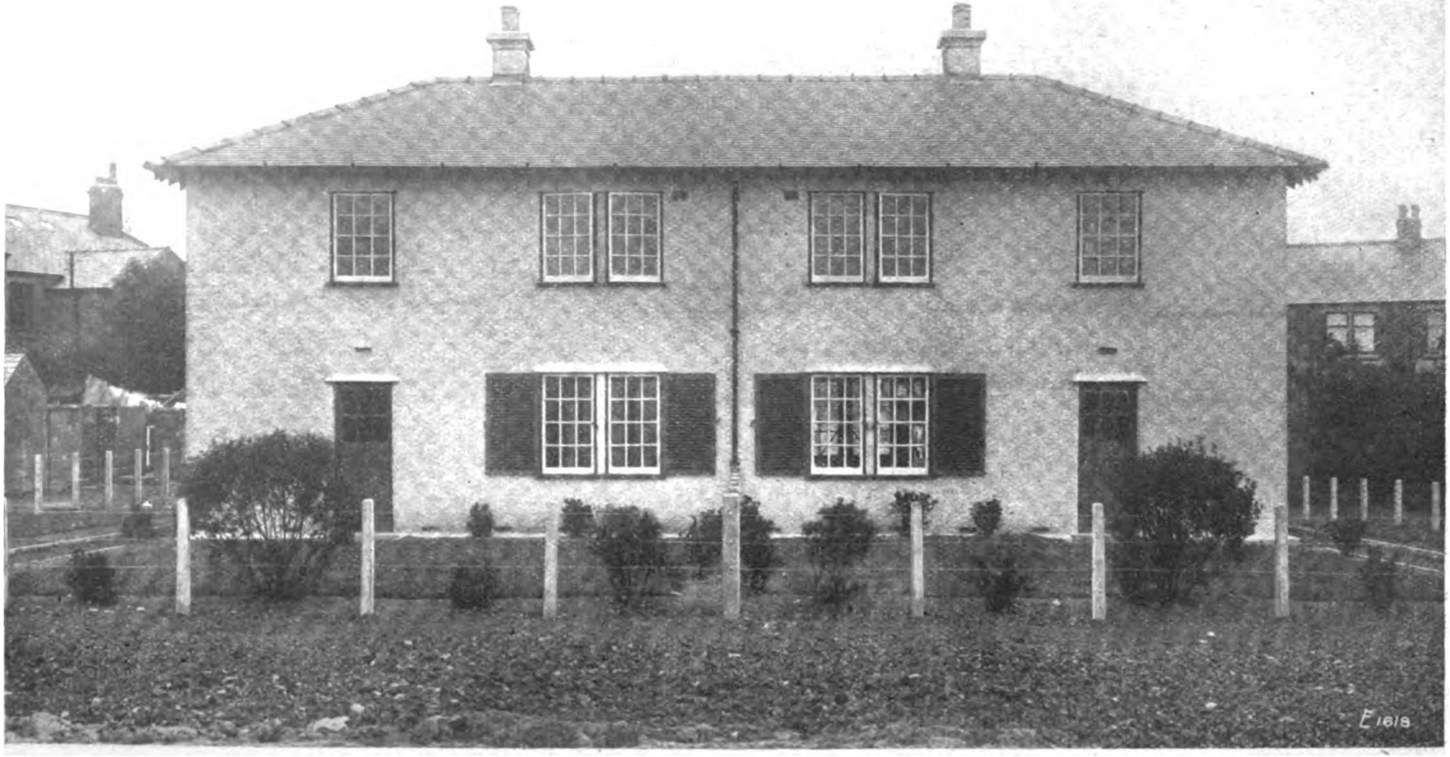


COTTAGES AT BLACKPOOL.

*(For description see page 591)*

# CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XV. No. 9. LONDON, SEPTEMBER, 1920.

# *EDITORIAL NOTES.*

## EXPERIMENTS WITH THIN WALLS.

EVERY argument that is being used against concrete as a house building material is gradually receiving redargution, either from the actual experience with completed works, or from the results of experiments. Two of the most persistently heard and oft-repeated arguments of this kind are that the thin wall, for the construction of which concrete is so admirably suited, lacks strength when subjected to a crushing strain, or stability when subjected to horizontal stresses, and that its co-efficient of heat transmission is high, leading to an inequable temperature within the house and to consequent condensation.

The results of the experiments which appear in the recent advance report of the Building Materials Research Committee under the Department of Scientific and Industrial Research, some of which we published in our August issue, show that there exists but little justification for even these charges of inefficiency.

Three experiments were undertaken to test the strength of thin walls, and these comprised crushing small blocks of the material, crushing narrow thin walls 8 ft. 6 in. high—the average height of an unsupported wall in a small house—and subjecting small lengths of wall, of a similar height and loaded vertically, to horizontal pull. The walls were built with various materials, such as stock bricks or flettons, with cement mortar and lime mortar, concrete blocks mixed dry and wet, concrete monolith, and coke breeze blocks. The results show that the crushing strength of a wall built of concrete blocks, mixed 1 : 2 : 4 4½ in. thick, is greater than one of equal thickness built with flettons in cement mortar, whilst its resistance against a horizontal pull is nearly double; that a wall of concrete blocks, made by the wet process, 3 in. thick, has likewise a greater crushing strength, whilst its resistance to a horizontal pull is somewhat less than stocks or flettons built with cement mortar, but is greater than the latter if built in lime mortar.

To determine the coefficient of heat transmission various materials were carefully and scientifically tested. And these tests result in proving that a 10 in. concrete cavity wall, composed of 4 in. ballast concrete on the outside, with 4 in. coke breeze concrete on the inside, leaving a 2 in. cavity, has a lower coefficient than any other material which was subjected to similar tests. The experiments also show that a 4½ in. rough ballast concrete wall mixed 6 : 1 offers the least resistance to the passage of heat, thus proving conclusively the advantage of building with a hollow wall with an inner lining of porous aggregate.

There is no doubt that tests and experiments of this kind are of inestimable value, and we feel certain that any comparative test that is made between concrete and other materials, with a view of assessing their suitability for the construction of houses, will continue to show the former to an advantage. There are other qualities, in addition to strength and heat transmission, which might usefully be tested in a similar manner, and be set out in comparative tables.

### CONDITIONS IN THE BUILDING INDUSTRY.

MATTERS of far-reaching importance, which, if carried into effect, would affect concrete construction as much as every other branch of the building industry, were brought up for consideration at the annual meeting of the Industrial Council for the Building Industry (The Building Trades' Parliament), at Montagu House, Whitehall, on August 12th and 13th.

The report around which the most interest centred, that of the Management and Costs Committee, was, however, not fully discussed, as owing to the late hour at which it came up for consideration it was felt that the divergent views which it had aroused could not adequately be expressed, and a two days' meeting of the Council is called for November 11th and 12th for the special purpose of considering the report, and, if possible, coming to some decision. The drastic recommendations of this report provide for the elimination of the employer *qua* employer, and the substitution of a managing committee, consisting of representatives of the present employers and operatives, to control the whole building industry of the country. The present master builders and contractors would be paid a salary, to be called the "wages of management," based on the sum which after investigation is determined as the amount they are receiving for services rendered to their respective undertakings, any vested interest or return on capital to be considered separately. The operatives would be paid during unemployment and during inclement weather when they are unable to work, and there are also provisions for the payment of pensions to the operatives at the age of 60 and, in the event of their death, to their wives and dependents. The proposals, in fact, aim at the entire reorganisation of the building industry very much on the lines of the building guilds which are now operating in one or two places, and would create a state of affairs which, from the operatives' point of view at any rate, can only be called Utopian.

The Management and Costs Committee consists of sixteen members (eight employers' representatives and eight operatives' representatives), but only two of the employers' side signed the report. At the Council meeting this divergence of opinion was even more clearly marked, and at one time looked like being the cause of the dissolution of the body altogether; indeed, when the formation of the new Committee was under consideration, although the operatives re-elected their representatives *en bloc*, not a single nomination was forthcoming from the employers, and the *impasse* was only overcome by the postponement of the business until the following day, when, as already stated, it was put off for a further three months.

There is much to be said for some of the proposals, such, for instance, as the payment of at least some portion of the wages for time lost through stress of weather, over which the men have no control; loss of income does not arise from this cause in most other industries, and has always been the cause of discontent in the building trade. With this and some of the minor proposals a section of the employers expressed a certain degree of sympathy, but it is hardly likely, and surely the operatives cannot expect it, that they would agree to that part of the report which practically provides for the alteration of their status from that of master contractors to paid servants of a " managing committee," working under supervision. The proposals appear to represent the ideals of the most advanced Socialists, but the unsettled state of the building industry and the critical financial condition of the country renders the present time particularly unsuitable for any interference with the fundamental principles on which the industry has satisfactorily been carried on in the past.

Another matter about which very strong opinions were expressed on both sides was the Government proposals for expediting work on housing schemes. These proposals, in addition to provisions for the freer admission of apprentices, proposed that working hours be fixed at 50 per week in summer and 39 per week in winter, with the object of eliminating as far as possible time lost through bad weather. A guaranteed week was offered of 35 hours in summer and 26 in winter at full rates of pay. and the rest of the time at half rates. If required, trade unionists would have to be allowed to work overtime at the current rates. As a *quid pro quo* for these concessions, the operatives were required to consent to working on a system of piecework, or payment by results (the men to be consulted in the fixing of prices and to be guaranteed a minimum wage per hour for a certain output), and also to permit the training and admission into the industry of ex-Service men.

These proposals, which had to be accepted in their entirety, as framed applied solely to labour on housing work, but past experience has shown that concessions granted to one industry are claimed by, and generally granted to, other entirely unrelated industries, and, therefore, it is inevitable that any improved conditions granted to one section of a particular industry must ultimately, and probably very soon, be given to the whole. In considering these proposals, both the employers' and operatives' representatives on the Council were, although for different reasons, unanimous in their condemnation. The deep-rooted objection of the operatives to piecework and dilution of labour was freely expressed by their representatives, who definitely refused to consider any scheme which embodied such proposals. The proposals were considered by the Resettlement Committee, which announced that it was of the opinion that they " showed such a lamentable ignorance of the position in the building industry that an effective reply should be made." A Sub-Committee was, therefore, appointed to confer with the Cabinet Housing Committee, and that meeting took place on August 17th.

As was to have been expected, the proposals for piecework and the grading up of labourers to do skilled work were definitely rejected. The deputation, however, realised the necessity for increased output, and put forward a counter-proposal for the training of adult apprentices up to the age of 26. It was agreed that the Government might at once indemnify men engaged on housing work from loss of income through wet weather, as the Resettlement Committee was already considering a scheme on the same lines to apply to the whole of the industry. The proposals in regard to overtime were also agreed to, subject to safeguards. This partial acceptance was not, of course, acceptable to the Government, which had stipulated that the proposals should be taken as a whole, and as a result new proposals were to be formulated and submitted on behalf of the Government.

In considering these proposals, no doubt what is uppermost in the minds of the operatives is the long periods of unemployment which they experienced before the war, and in this we are in entire sympathy. But we would appeal to them to look at the matter in the light of present-day circumstances. There is no possibility of unemployment in the building trades for many years to come, and the public are clamouring for houses. If the industry does not arrange within itself to supply these houses at a much more rapid rate than at present, there is every probability that the matter will be taken out of its hands entirely. It is essential for the national welfare that the houses should be built, and if employers and operatives endeavour to see both sides of the question the present difficulties should not be insurmountable.

## LONDON SCHOOL BUILDINGS.

IN the past the school buildings of the London County Council have been almost exclusively constructed in brickwork, but a recent publication of the Council, on its future education schemes, in a section devoted to school architecture indicates that other materials may be resorted to in the near future. Owing to the increased cost of building, it is stated, the strictest economy will have to be exercised, and this, it is thought, may be effected to some extent by the use of less expensive materials. The almost sole use of brick in the past was largely influenced by the restrictions of the London Building Acts, and the building by-laws, but now that school-building in the Administrative County of London is exempted from these regulations as to construction and material it is highly probable that newer and cheaper materials will be adopted ; indeed, the publication before us strongly advises the use of different and lighter construction, and states that "school architecture would benefit from the adoption of other materials than brick and stone." The erection of many contemplated schools was postponed at the outbreak of war, and others are now necessary on account of the natural increase in population ; the result is that a large number of new schools are now an urgent necessity and the adoption of cheaper forms of construction would, in the aggregate, amount to a very considerable economy.

## GENERAL NOTES.

**Special Methods of Construction.**—As we go to press we notice that a recent number of *Housing* contained an article entitled "A Review of Special Methods of Construction." Further reference to this article will be found in our next issue.

**Hydrated Lime in Concrete.**—In the current issue we publish an article by Mr. A. E. Wynn on the use of hydrated lime in concrete roads We have also received a report on some tests made to ascertain the effect of hydrated lime and other powdered admixtures on concrete generally, to which we shall refer fully in a subsequent number.

**Rules for Flat Slab Design.**—It is interesting to observe that the City of New York has recently adopted regulations governing reinforced concrete flat slab design and construction. These rules came into force on August 20th, and as they are of interest to the reinforced concrete industry generally, we propose publishing them in our next issue.

# CONCRETE COTTAGE BUILDING.

---

## COTTAGES AT BLACKPOOL.

THE variety of ways by means of which it is possible to utilise concrete as a material for cottage building seem to be almost endless, and it is still not possible to announce a verdict in favour of any particular method ; it is essential, however, to keep an open mind and examine each, both theoretically and practically on its merits.

The system adopted at Blackpool for the erection of some cottages, which are illustrated this month, seems to have great possibilities, and its development should be watched with considerable interest. The principle of the system is that of a reinforced concrete frame, the members of which are all pre-cast, the panels, formed between the members, being filled with a hollow wall of blocks, the outer leaf being of an impervious mixture, and the inner of a porous mixture, to prevent condensation on the inner wall surfaces.

Certain of the pre-cast columns are made with a through hollow ; this is a particularly interesting point, for it means that the hollow of the outer wall is just as complete as it would be with an ordinary cavity wall block construction. The solid concrete foundations are built up to above the level of the ground, and on to these the main vertical pre-cast members are built, the various members themselves being bolted together, holes being made during the casting for this purpose. It is interesting to note, however, that these bolts are not subjected to any shearing stresses whatsoever, since the various members are cast with brackets and offsets, so that when the parts are assembled, the bolts could be removed without affecting the stability of the structure, unless subjected to a rocking motion.

*Fig.* 1 shows the framework during the process of assembly with a large portion to the upper floor about to be raised into position. The various members can either be cast in moulds on the site or in the builder's yard ; or, in the case of several neighbouring jobs, at a central depot. The Ministry of Health, by whom this system is, of course, approved, insist that all pre-cast members shall lie on their beds for at least five weeks before being used. *Fig.* 2 shows some of the members in the yard of Messrs. Parkinson & Son at Blackpool. This yard was situated quite near to the site. On the left side of the illustration is seen an empty mould with the reinforcement, which can plainly be distinguished, in position. This reinforcement consists of ⅜, ½, ⅝ or ¾ in. rib bars. The size, of course, depending on the position of the member and the load to be carried.

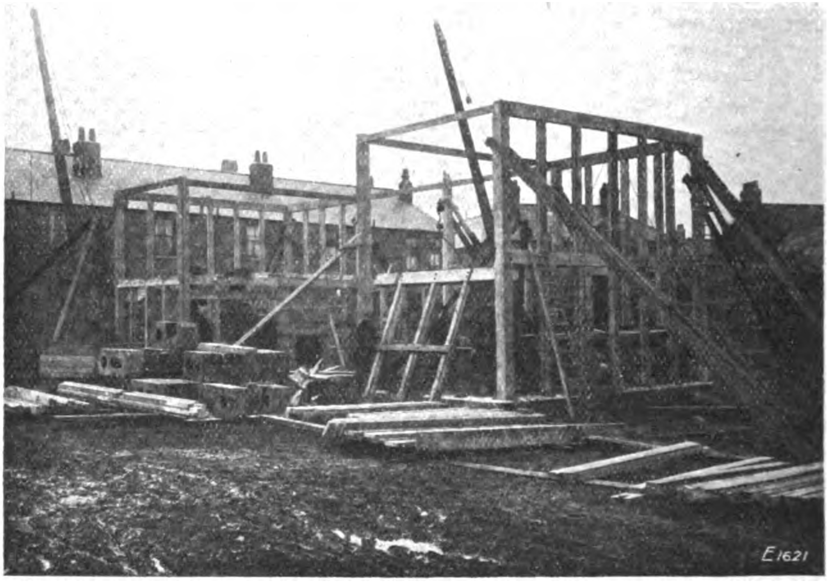


Fig. 1. Showing Framework during process of assembly.

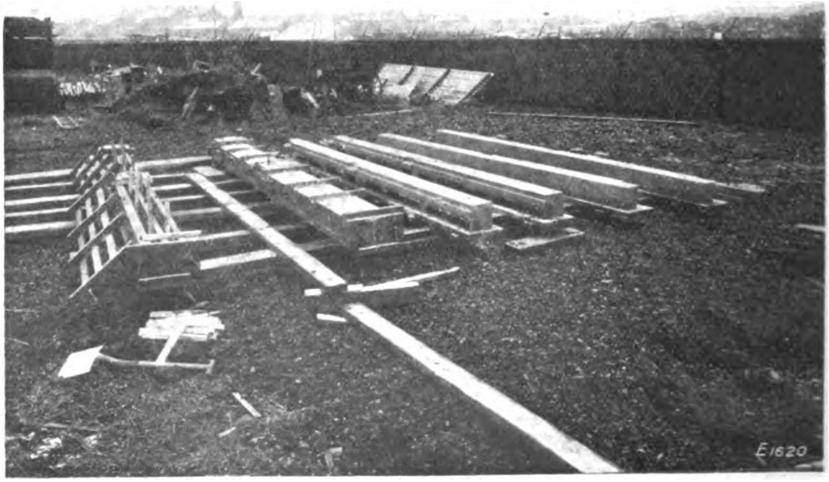


Fig. 2. Showing some of the pre-cast members. (One of the members is seen on the left with the reinforcement in position.)

COTTAGES AT BLACKPOOL.

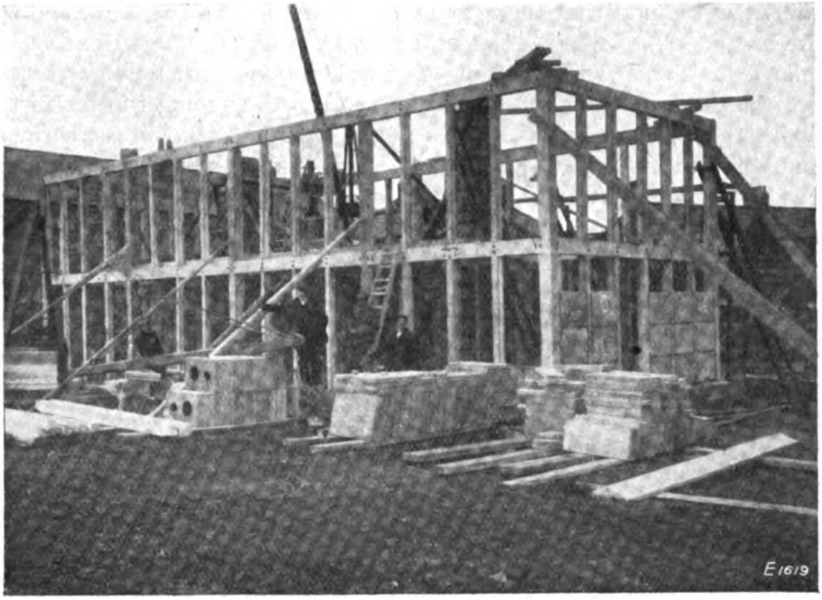


**Fig. 3.** Showing framework of a pair of cottages almost completed, and blocks on end wall being built up.

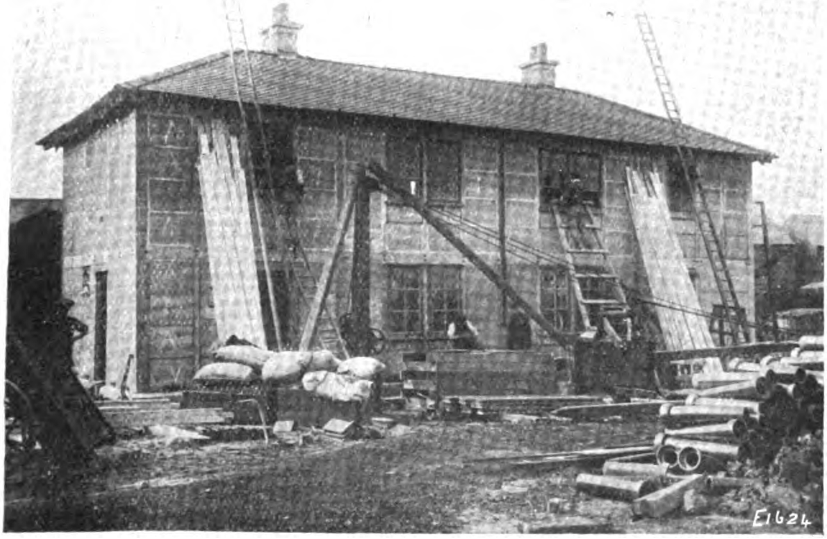


**Fig. 4.** A pair of cottages after 14 days from the commencement of work. Walls ready for external rough-casting or plastering.

Cottages at Blackpool.

The mixture for these particular cottages consisted in the first place of 1 : 1½ : 3½, but later it was found that the aggregate contained sufficient sand, and so the mixture became a 5 to 1 one. As has already been stated, the pre-cast columns are hollow, the two portions being joined at intervals with reinforcement. In some of the other members in *Fig* 2 the methods of framing can distinctly be seen, both the housings and bolt holes being apparent. It will furthermore be observed that the members are rebated ; this is to take the inner and outer main wall blocks, which are 2 in. thick, having a 3½ in. cavity between them. *Fig.* 3 shows the framework to a pair of cottages almost completed, with the blocks on the end wall being built up. The large concrete flue blocks should be noted, together with the fact that there is practically no scaffolding.

The floors are constructed of pre-cast reinforced joists, 7 in. deep, having wood slips sunk on the upper sides for the attachment of the floor boards, and being rebated on the underside to take asbestos sheeting, which forms the ceiling. The roof is of ordinary timber construction.

Although this method of construction is claimed to be cheaper than brickwork, the especial emphasis is placed rather upon the great speed with which the houses can be built than upon the price. The frame itself can be erected in almost a few hours. *Fig.* 1 shows the cottages after only 20 hours' work. The whole house, it is claimed, can be completed and ready for occupation in about four to six weeks, the actual erection of walling being about eight times as rapid as with brickwork. *Fig.* 4 shows the state of affairs after 14 days from the commencement of the job, the house being then ready for external roughcasting or plastering. At the present time, when so much difficulty is being experienced in obtaining either skilled labour or bricks in sufficient quantity, the existence of a system which permits of such speed is particularly valuable.

At present the pre-cast members are standardised to three types of plan, even this, however, allows of considerable flexibility of the internal arrangements, most of the partitions being moveable without interfering with the standardisation. Where, however, it were intended to build a large number of houses, and a variety of type plans were required, it would be a simple matter to make moulds for casting the members to special sizes, without adding to the cost of the scheme.

The frontispiece illustration shows a view of the finished houses. It will be noticed that they are particularly simple and well proportioned.

The idea of this particular system emanated from Messrs. Jacob Parkinson & Sons (Blackpool), Ltd., who approached the Trussed Concrete Steel Co., Ltd., who are well-known technical experts in reinforced concrete work. Several experiments were jointly carried out, and the cottages at Blackpool were erected by Messrs. Parkinson and Sons. These cottages appear to have been so successful that the contractors were unable to cope with the demands from different parts of the country. It was therefore decided to form " The Pre-cast Housing Association (Parkinson-Kahn System)," which selected contractors, each having a definite area for operation have been asked to join. Knowing how essentially work of this kind requires both experience and conscientious supervision, lack of which would soon bring the whole system into discredit, the originators of the scheme have been careful to invite only firms of thoroughly good repute in this class of work. The whole scheme would seem to be a very apposite attempt to alleviate the housing shortage, and one which is capable of great developments along similar lines. It is a steel-framed structure in which the steel frame is replaced by reinforced concrete members, which are both cheaper and quicker to manufacture, lighter and easier to handle, more rapid to assemble and, moreover, they make use, to a large extent, of local material, in that the bulk of the substance is local aggregate. It would seem that the line of development should be similar to steelwork, which, with its standardised sections, can be cut to any length and assembled however required. For ultimate success it is absolutely essential that the utmost flexibility be obtained, so that the design determines the structural method rather than the structural method determining the design.

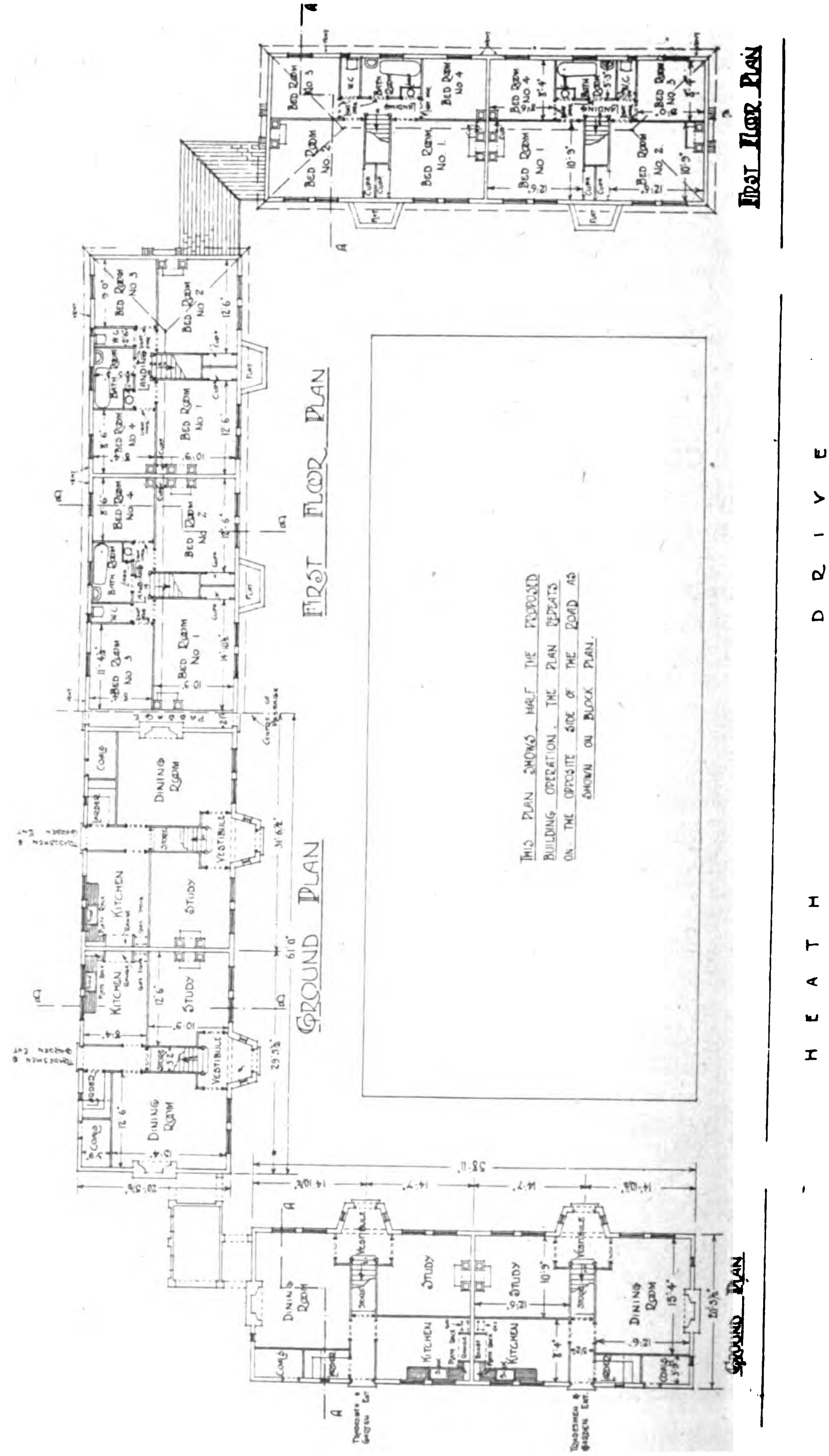
## .COTTAGES IN HERTFORDSHIRE.

In the January issue was given a description of some cottages which it was then proposed to erect at Potter's Bar. The system to be employed was that of Messrs. Concrete Buildings, Ltd., which consists of a cavity block, mixed wet, and manufactured in moulds, composed, on the outside, of impervious concrete and, on the inside, of breeze concrete, the joint between the two parts being reinforced with wire, and the webs containing a vertical damp-proof course, without which the efficacy of the hollow would, to a large extent, be lost.

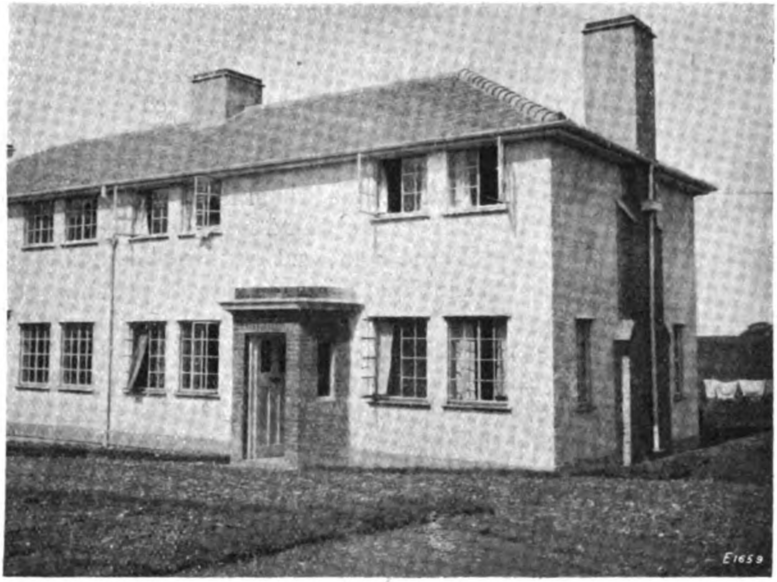
As the whole system was very fully described at the time, it is not proposed to repeat the information; the cottages, are, however, now completed, and the three photographs give a good idea of their appearance, both interior and exterior. The whole group of 16 houses, most of which are inhabited, is arranged in the form of a quadrangle, through the centre of which runs a new approach road—Heath Drive—which is not yet made up, the general lay-out of the group

General View.

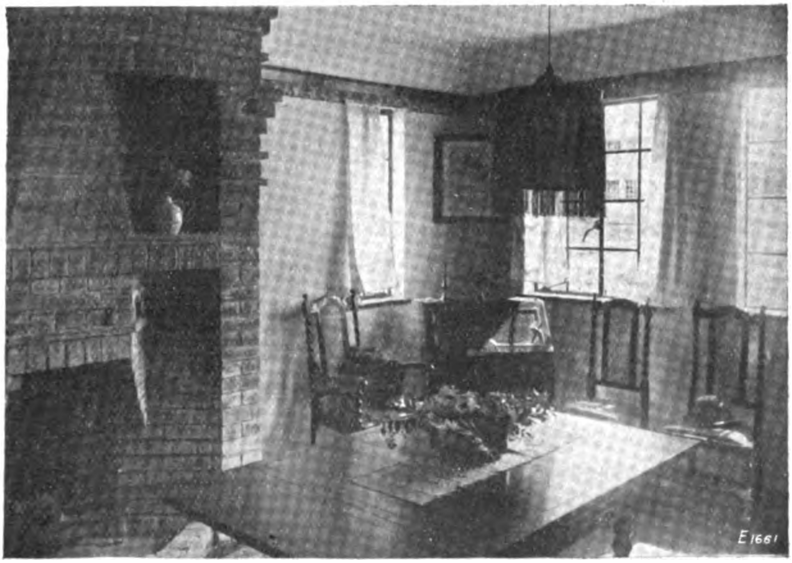
Houses at Potter's Bar.



Plans.
Houses at Potter's Bar.



A Corner House at Potter's Bar.



View of Sitting-Room.

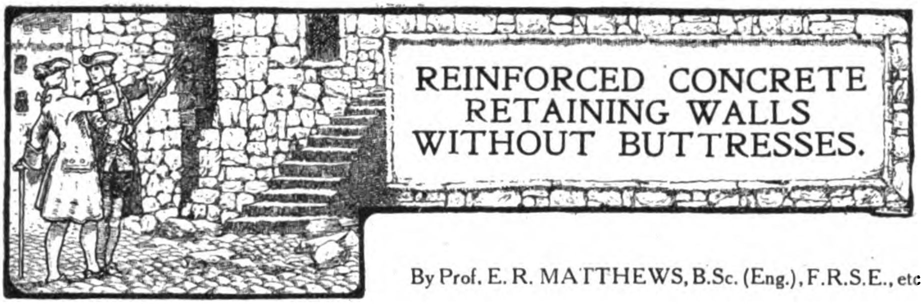
HOUSES AT POTTER'S BAR.

—half of which is shown on the plan on page 596—is very pleasant, and the general effect of the white walls and the red brick porches is extremely satisfactory. Particularly well-coloured slates with finely graduated tones have been used, and this contributes not a little to the general impression.

The interior of the houses appears to be equally satisfactory. Although a visit was paid during the recent spell of wet weather no trace of dampness was met with. A particular feature has been made of the fireplace opening in the living-room, which has been executed in unplastered brickwork. The design is somewhat too heavy for the size of the room, which it seems to dominate. A somewhat simpler design of a similar nature would have been more suitable.

The houses are served with electric light, and gas for cooking and heating the water supply, and the general internal arrangements of planning are very satisfactory. The projecting porch gives a certain air of spaciousness on entering which is so often lacking in a similar type of plan in which the staircase is approached directly opposite the front door. The design of the front doors is actually not very successful, and ill-harmonious with the otherwise quiet and subdued tone of the house, and the appearance would be improved by the substitution of a simple glazed panel for the leaded coloured lights.

Apart from these slight defects, however, the houses appear to be entirely successful, and it is understood that several cottages are being built elsewhere on the same system. The contractors for this group were Messrs. W. Alban, Richards & Co., Ltd.



# REINFORCED CONCRETE RETAINING WALLS WITHOUT BUTTRESSES.

By Prof. E. R. MATTHEWS, B.Sc. (Eng.), F.R.S.E., etc.

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It is often found impossible owing to lack of space to construct reinforced concrete retaining walls with buttresses or counterforts, and so without these they must be of a heavier design. Where a wall such as that shown in *Fig.* 1 acts as a reservoir wall holding up water, and at the same time as a retaining wall holding up soil, as the water pressure on the vertical wall is greater (nearly double) than the earth pressure, in practice the wall is designed as if intended for water pressure on both sides, consequently the amount of reinforcement is the same.

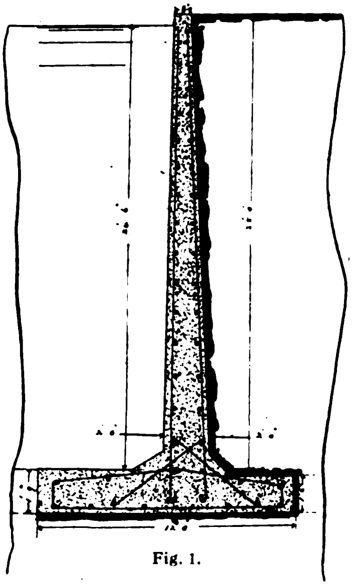

Fig. 1.

The earth pressure can be calculated if the wall is vertical by the well-known formula :—

$$\tfrac{1}{2}\, w\, h^2 \tan^2 \frac{90-\phi}{2}$$

and the pressure at any depth by the formula

$$w\, h \tan^2 \frac{90-\phi}{2}$$

The total pressure of water will be

$$\frac{w\, h^2}{2}$$

and the pressure at any depth $= w\, h$. The difference in the water and earth pressures will be :—

$$\tfrac{1}{2}\, w\, h^2 \text{ of water} - \tfrac{1}{2}\, w\, h^2 \tan^2 \frac{90-\phi}{2} \text{ of earth.}$$

*Fig.* 2 represents a reinforced concrete retaining wall, the outer face being in compression, and the inner face in tension. The vertical bars take the whole of the tensile stresses, the horizontal bars being inserted as stiffeners. It is very necessary that the base of the wall should be widened out as shown, and the vertical bars must be hooked on to the bars at the base of the foundations. It is usually desirable to put in rubble packing at the back of such a wall so as to allow any subsoil water to get away, and many walls have failed through this precaution not having been made. In building retaining walls, whether intended to resist water or earth pressure, or both, it is advisable to use a somewhat " wet " mixture, as this insures that the reinforcement will be well coated with cement, and corrosion will thus be prevented.

As the amount of reinforcement required will be greatest at the base of the wall, and will diminish the higher up the wall we get, it is usual in practice, as the vertical bars cannot be reduced in size, to carry some of them only half way up the wall as shown in diagram *Fig. 2a* The horizontal bars should be less in diameter the higher up the wall we get ; it is convenient to make these (in, say, a 20 ft. wall) ¾ in. diameter in the bottom third of the wall ; ⅝ in. in the next third, and ½ in. in the top third, spaced at about 12 in. centres. The concrete should be in the proportions of 4 : 2 : 1 (four parts broken stone or gravel, to pass through a 1 in. ring, two parts sand, and one part cement) ; some engineers and architects prefer a 3 : 1½ : 1 concrete.

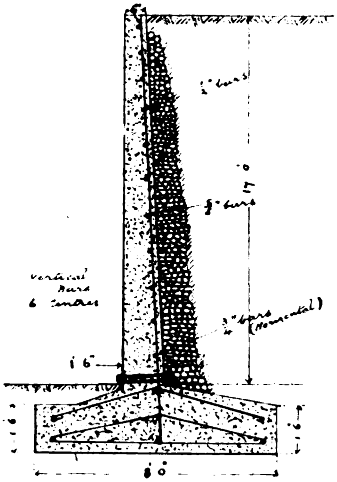

Fig. 2.

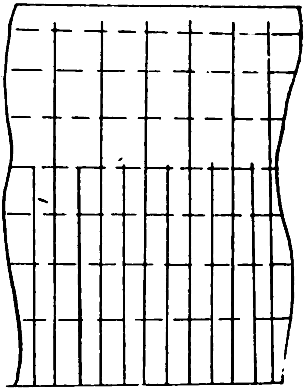

Fig. 2a. Elevation of Reinforcement at back of wall shown in Fig. 2.

The working stresses may be taken as :—

| | |
|---|---|
| Steel in tension .. .. .. .. | 16,000 lb. per sq. in. |
| ,, compression .. .. .. | 12,000 ,, ,, |
| ,, shear .. .. .. .. | 8,000 ,, ,, |
| Concrete in compression .. .. .. | 600 ,, ,, |
| ,, shear .. .. .. .. | 60 ,, ,, |
| Adhesion of concrete to steel .. .. | 100 ,, ,, |

*Weights of various substances* :—

| | |
|---|---|
| Reinforced concrete .. .. .. | 144 lb. per cu. ft. |
| Brickwork .. .. .. .. | 112 ,, ,, |
| Sandstone .. .. .. .. .. | 140 ,, ,, |
| Coal .. .. .. .. .. | 56 ,, ,, |
| Coke .. .. .. .. .. | 28 ,, ,, |
| Water .. .. .. .. .. | 62·4 ,, ,, |

*Angles of repose of various substances :—*

| | |
|---|---|
| Sand (dry) | 30° to 37° |
| Sand (wet) | 26° |
| Clay, with gravel | 38° |
| Gravel | 48° |
| Shingle | 39° |
| Vegetable earth (dry) | 30° |

*Typical example of how to design a reinforced concrete retaining wall, without buttresses, 17 ft. high above the foundation slab, to retain sand moderately dry for the full height of the wall.*

We will take the " angle of repose " of the sand as 30°, and assume that the thickness of the wall at the top is 6 in., and at the base 1 ft. 6 in., or about one-tenth of the height (see *Fig.* 2).

The pressure at the back of the wall must next be ascertained ; this may be done by calculation, or graphically. We will take the first method.

To find out $P$, which is the horizontal thrust at the bottom of the wall, use (as we have already said) the following formula :—

$$P = w\,h \tan^2 \frac{90-\varphi}{2}$$

where $w$ = weight of a cu. ft. of the earth,
$h$ = height of wall in ft.
$\varphi$ = angle of repose for the earth.

Assume that the weight of the earth is 100 lb. per cu. ft. :

$$h = 17 \text{ ft.}$$
$$\varphi = 30^\circ$$

we get :—

$$P = 100 \times 17 \times \tan^2 \text{ of } 30^\circ = 1{,}700 \times 0{\cdot}5774^2 = 566 \text{ lb.}$$

This is one-third of the vertical pressure on the soil at this depth.

$P$ will therefore equal

$$\frac{w\,h}{3}$$

The total thrust equals

$$\tfrac{1}{2}\, w\, h^2 \tan^2 \frac{90-\varphi}{2}$$

By $T = \dfrac{Ph}{2}$ we get $T = \dfrac{566 \times 17}{2} = 4{,}811$ lb.

$T$ = Total thrust.

The centre of pressure is opposite the centre of gravity of the triangle, which is one-third the height of the wall.

We will now endeavour to find the bending moment, treating the wall as a cantilever, the base being the fixed end.

$M$ = the load multiplied by the distance of its centre of gravity from the fixed end =

$$\frac{Th}{3} = \frac{4{,}811 \times 17 \times 12}{3} = 327{,}148 \text{ in.-lb.}$$

As the thrust and bending moment diminish towards the top of the wall, it is usual in practice to take the B.M. at various heights in the wall, and to ascertain the thickness of the wall, and the amount of reinforcing steel necessary at these various heights. Having shown how these can be calculated, the author does not intend to work out any examples.

As to the amount of reinforcement necessary at the base of the wall we are considering, for the economic section we may proceed as follows :—Assume a good concrete 4 : 2 : 1, and $m=15$, then the thickness at the base equals

$$d=\sqrt{\frac{M}{0{\cdot}158\,b\,c}}\,;\quad M=327{,}148 \text{ lb.}$$

Taking 1 ft. run of the wall, and $c$ as 600, we get :—

$$d=\sqrt{\frac{327{,}148}{0{\cdot}158\times 12\times 600}}=\sqrt{287{\cdot}48}=16{\cdot}97 \text{ in.}$$

say 18 in. thickness of wall at base, as shown in *Fig.* 2.

Area of reinforcement necessary :—

$$a=p\,b\,d$$

and $p=0{\cdot}00675$.

Hence $a=0{\cdot}00675\times 12\times 18=1{\cdot}458$ sq. in.

Using 1 in. round bars at 6 in. centres will be ample reinforcement

*Width of Foundation Slab* :—It is usual to make the thickness of this about the same as that of the base of the wall. As to the length (or width) of the foundations, these may be arrived at by means of the formula :

$$l=\sqrt{\tfrac{1}{3}\,h^2\tan^2\left(45-\frac{\varphi}{2}\right)}.$$

For stability the actual length of base should be not less than

$$L=1\tfrac{1}{2}\,l.$$

The theoretical length of base in the case given will be :—

$$l=\sqrt{\tfrac{1}{3}\,h^2\tan^2\left(45-\frac{\varphi}{2}\right)}$$

or $\quad l=\sqrt{\tfrac{1}{3}\times 17^2\times{\cdot}577^2}=5{\cdot}66$ ft.

We said that for stability the length of base $L$ should equal $1\tfrac{1}{2}$ times the theoretical length $l$, therefore $5{\cdot}66+283=8{\cdot}49$, say 8·5 ft.

*Reinforcement for Foundation Slab* :—The top of a foundation slab is in compression, and the bottom in tension ; the portion at the back (the heel) will be in tension on the top, and compression on the under side. The correct depth for the placing of the bars, and the area of reinforcement necessary can be determined by the formulæ :—

$$d=\sqrt{\frac{M}{0{\cdot}158\,b.c.}}$$

$$a=p\,b\,d.$$

The B.M. at the wall line will equal the load outside this point multiplied by the distance of its centre of gravity from the wall.

# THE CONCRETE INSTITUTE.

## MONTHLY NOTES.

By the SECRETARY.

### STANDARD NOTATION FOR ENGINEERING FORMULÆ.

**Erratum.**—In the issue for August on page 563 under the above heading, the example of middle point (see Section 2) should have shown a **point**, not a **dash**, between **m** and **r**, thus, **m·r.**

### SOUTHWARK BRIDGE RECONSTRUCTION.

By the kind permission of the contractors, Sir William Arrol & Co., Ltd., and with the co-operation of the engineers, Messrs. Mott, Hay & Anderson, of Westminster, a visit has been arranged to the engineering works of the new Southwark Bridge, London, for September 18th, at 3 p.m. The following notes have been kindly supplied by the engineers :—

The work comprises the removal of the old Southwark Bridge and the erection on the same site of a new bridge with improved gradients.

The old Southwark Bridge consisted of three C.I. arches, the largest span being 240 ft. The bridge was designed by Rennie and was opened to public traffic in 1819.

The Corporation of London decided upon its removal on account of the steepness of its gradients, 1 in 18 on the City side, and because its piers were out of alignment with the other bridges in the vicinity.

The new bridge consists of five steel arches, and the worst gradient is about 1 in 33.

At the present stage the new piers have been completed and the steel superstructure is being erected.

The piers were built upon caissons sunk into the river bed to 50 ft. below high-water level.

The caissons were 102 ft. long by 30 ft. wide and weighed about 200 tons and were sunk under compressed air ; the piers were built upon the caissons as they sank, temporary caissons being provided so that the work was carried out in the dry.

Each of the steel arches is constructed with seven ribs, all of which have been erected.

They were put into position by slinging them from overhead girders supported by the footbridges which have been provided for the use of the public.

The steel flooring is being laid upon the ribs and the concreting of the roadway and footpaths will shortly follow.

The old bridge was 42 ft. 6 in. wide between parapets ; the new will be 55 ft., made up of two footpaths each 10 ft. wide and a roadway 35 ft. wide.

The work was started before the war, the contract price being £280,000 ; it was shut down under Government orders and restarted soon after the armistice.

The contractors are Messrs. Sir William Arrol & Co., Ltd., Glasgow.

## CONCRETE AGGREGATES.*

(*Continued.*)

| | (5) **Ascot (Berkshire).**— | (6).— |
|---|---|---|
| *General description :* | Gravelly stones with some sand. | Thames ballast. |
| *Source and locality :* | At Kennet side. | Windsor or Old Windsor. |
| *How obtained :* | By digging. | By dredging. |
| *From whom obtained :* | William Watson (Ascot). | Thames Conservancy Dredging Company. |
| *Is available quantity limited ?* | Yes, for want of labour to dig it. | No. |
| *Present maximum output per day :* | None at present. | † |
| *Transport facilities :* | Cartage. | Cartage or motor. |
| *Is there any provision at or near source for washing or crushing ?* | No. | No. |
| *Price per c. yd. and where delivered :* | 6s. per yd. at the pit. | † |
| *Is composition uniform ?* | Fairly so. | Fairly. |
| *Kind of stone or coarse material :* | Gravel mixed in size. | † |
| *Kind of sand or fine material :* | Variable sand and gravel. | |
| *Relative proportions, coarse and fine :* | About equal quantity of stone and sand. | |
| *Shape of particles :* | Angular (can be used in concrete). | |
| *Approximate percentage needing crushing to pass ¾ in. screen :* | About 50 per cent. | |
| *Impurities :* | A little clay. | |
| *Notes :* | Makes fairly good concrete.<br>Fully two miles from railway station. | |

(7) **Bath (Somerset.)**—Mendling limestone; very hard; often used in place of granite for finishing. (R.C.B.)‡

(8) **Bedford.**—Gravel obtainable containing 7½ per cent. of loam. (R.C.B.)

(9) **Berwickshire (East).**—The usual source is said to be gravel from the river bed or the beach.

(10) **Birmingham (Warwickshire).**—Sand containing 22½ per cent. of loam. (R.C.B.)

Considerable quantities of blast-furnace slag, purchased ready broken, is used. Price varies from 5s. 6d. to 9s. 6d. per ton, according to place of delivery. The City Authority also uses discarded paving setts, bricks and other road materials; these are broken up by hand or machine at the various wharves, where they are lying. Speaking broadly, the only general material available in the City for concrete is rounded gravel, and in place of this it is better to use broken slag, which has to be procured from places ten miles away or more.

(11) **Bolton (Lancashire).**—Good sand is obtainable. (R.C.B.)

(12) **Bradfield R.D. (Berkshire).**—

*General description :* Thames Valley ballast and Plateau gravel.
*Locality :* Most parishes.
*How obtained :* Dredging and ordinary digging.
*From whom obtained :* Various owners.
*Quantity available :* Unlimited.
*Transport facilities :* Council's steam wagons, etc.
*Is there provision at or near source for washing ?* Yes, in several cases.

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* See also issue of August, 1920.

† No information supplied.

‡ Items marked "R.C.B." are from information kindly furnished by Mr. R. C. Branston and forwarded by the British P.C. Manufacturers, Ltd.

*Price per c. yd.:* 3s. to 4s. 6d., dug at pit; extra for washing and crushing or breaking.

*Is composition uniform?* No.

*Approximate percentage that needs crushing to pass ¾ in. screen:* Probably 25 per cent. to 30 per cent.

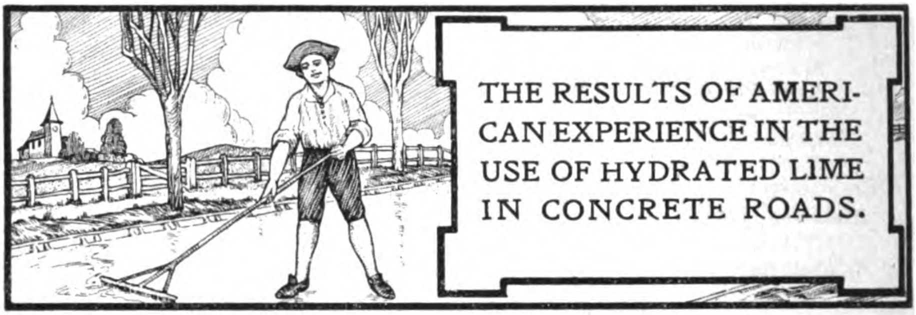
*Impurities present:* Clay.

*Notes:* Sufficient aggregate can be obtained near sites for concrete for erection of 200 to 300 houses, but concrete houses are not wanted.

(13) **Braintree (Essex).**—Gravel and sand obtainable, containing 30 per cent. loam. (R.C.B.)

(14) **Cambridgeshire.**—The County Surveyor states that "flint gravel mixed with sand is the only aggregate for concrete in Cambridgeshire. There may be river gravel at points in the Ouse. One pit of glacial drift gravel exists, but has been abandoned, owing to claims for extraordinary traffic. The remaining pits are of post-glacial valley gravel, following the valleys of the Ouse, the Cam and the Granta, and to a less extent those of the Rhee and the Bourn Brook. The bed of the Ouse and the lower reaches of the Cam in Cambridgeshire are mostly overlaid with peat."

See later for **Ely (Isle)**.



# THE RESULTS OF AMERICAN EXPERIENCE IN THE USE OF HYDRATED LIME IN CONCRETE ROADS.

By A. E. WYNN, B.Sc., Assoc.M.Am.Soc.C.E.

IN a previous article the writer pointed out the causes of cracks in concrete pavements and mentioned the fact that hydrated lime had been used extensively to assist in preventing cracks due to absorption of moisture. In this article he proposes to go into this subject more thoroughly.

Given good material and correct proportioning of ingredients, cracks resulting from the concrete itself are due principally to the absorption and expulsion of moisture.

This ability to absorb moisture depends largely on the amount of water used in mixing the concrete.

No material entering into the construction of concrete has more importance than the water, a fact which has only recently been recognised. Concretes mixed with the same proportions of cement, sand and stone, but with varying amounts of water, show compressive strengths that vary with the amount of water used, and even a stronger mix will show less strength than a weaker mix if too great an excess of water has been used. Now the hardest thing to control is the water ; the correct amount to use depends not only on the kind of cement and aggregate, but on the moisture content of the aggregate which may vary from day to day.

Another point to be considered is the practical one of the plasticity of the concrete. The correct amount of water that is required for complete hydration of the cement is not nearly enough to produce a concrete that is easily workable.

The consequence is that an excess of water has to be used and it is to this excess that most of the troubles in concrete are due.

As it is not easy to regulate the quantity of water it seems necessary to add to the concrete, during mixing, some substance that will correct the ill-effects due to the excess of water.

Hydrated lime has long been used in concrete as a waterproofing medium, and it is really for this purpose that it is being used extensively in concrete roads.

Hydrated lime is a very dry fine powder, produced by the slaking of quick lime under factory conditions. It is added to the cement during mixing in the proportion of from 5 to 10 per cent. by weight of the cement.

Engineers who have used hydrated lime extensively in concrete, claim for it that it functions in several ways all tending to produce a workable, uniform and denser concrete, which is thus less liable to crack.

The most noticeable effect of its use is the increased plasticity of the concrete, it will flow more easily through the mixer into the chute, and can be deposited with less labour in the forms and around the reinforcing. It really acts as a lubricant, allowing the sharper pieces of aggregate to flow more easily, and hence the cement, sand and stone are more evenly distributed, resulting in a denser and stronger concrete.

Just as much water is required, but it is held in suspension by the lime forming a creamy consistency which prevents segregation.

There is always loss of water in concrete roads due to evaporation and seepage to the subsoil. The addition of hydrated lime will tend to prevent this as it will retain sufficient moisture in the concrete until the cement has attained its initial set and is able to resist the shrinkage stress. This is important as many of the hair cracks in concrete roads occur between the time of pouring and initial set, when the concrete is weakest. Concrete roads are at all times exposed to the elements so that the densest possible concrete is required to prevent absorption of moisture. Waterproofing the concrete with hydrated lime will tend to prevent the alternate absorption and expulsion of moisture and hence the expansion, contraction and cracking.

Hydrated lime, because of its fineness, fills the voids in the concrete, making it denser and more impermeable to moisture.

Some engineers may object to adding hydrated lime to concrete on the grounds that it reduces the strength of the concrete. This, however, has not been decisively proved up to the present.

Tests recently made by Dr. Nathan C. Johnson would seem to indicate that the addition of lime does slightly reduce the strength of the concrete ; on the other hand, tests made by the State Highway Department of Delaware under field conditions, showed a slight increase in strength with the addition of hydrated lime in amounts up to 7½ per cent. by weight of the cement.

These seemingly irreconcilable results may, however, be explained by the fact that the former series of tests were made under laboratory conditions, where a drier and denser concrete can be obtained than in the field. The latter tests were made on concrete that was being placed on the road and cured in the same manner.

It is reasonable to suppose that hydrated lime will have a more beneficial effect on field concrete than on laboratory concrete. If we could obtain as good results in the field as in the laboratory there would be no need to add hydrated lime.

Hydrated lime has been used all over the United States in concrete road construction, and it seems to be the general opinion that it is beneficial, and the most economical way of improving the concrete.

## MEMORANDA.

**Pre-cast Concrete Road Slabs.**—The United States Bureau of Roads has approved of an experiment shortly to be carried out in Wyoming in the building of a concrete road with slabs cast 40 miles from the site. This innovation in road construction is apparently being resorted to owing to difficulties which would be encountered in housing any large number of workmen on the site and the absence of water. Such conditions are unlikely to be met with in this country, but for short sections of roads where aggregate and water are not readily accessible any extra cost might well be counterbalanced by the elimination of a pipe-line which otherwise might be necessary, and in any case the aggregate would have to be carted to the site. In the Wyoming experiment the road is to be 18 ft. wide, and the slabs are to be moulded 9 ft. sq. and hauled to the site of the road by motor trucks and trailers.

**Concrete Fence Posts.**—An economy is being effected on the construction of the Croydon relief road, four miles in length, from Thornton Heath to Purley by the use of concrete fence posts. The posts are 6 ft. in length and 6 in. by 4 in., and are made in moulds on the site of the new road. The cost works out at 6s. 8d. per post, which is less than oak posts of a similar size, while the life is, of course, greatly superior.

# SOME REINFORCED CONCRETE STRUCTURES IN AUSTRALIA.

By **E. G. STONE, Reinforced Concrete Specialist and Consulting Engineer, Adelaide.**

*In a recent number of the "Commonwealth Engineer," Mr E. G. Stone gives an interesting account of some of the reinforced concrete structural undertakings carried out in Australia under his supervision, and we are reproducing Mr. Stone's article and some of the illustrations from the above-mentioned journal.—ED.*

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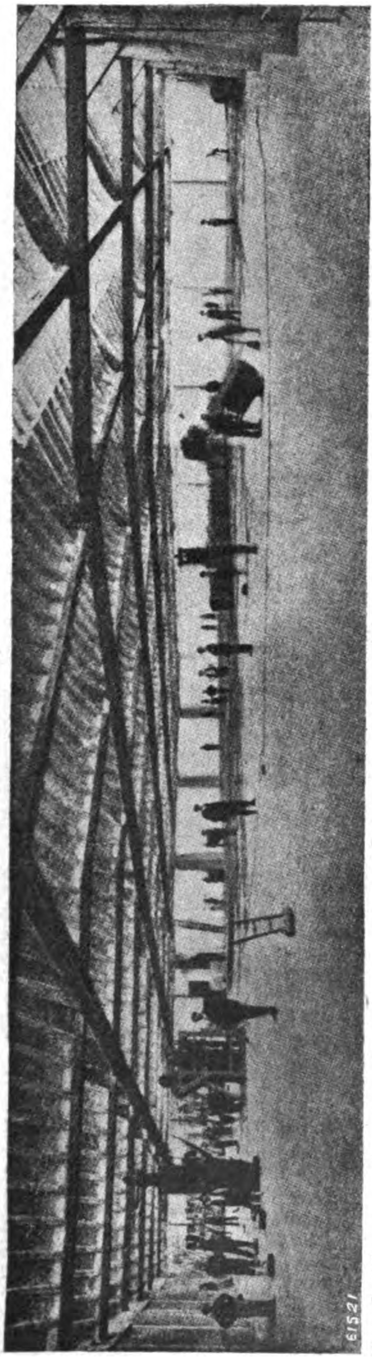
### WHEAT AND WOOL STORE.

SPECIAL construction was provided for this building, which was erected at Geelong, Vic., for Messrs. Denny, Lascelles, Austin and Co. The show floor is without columns. The span over all is 172 ft., and the whole area comprises 1½ acres.

There are, apart from the roof, two floors and a basement, making in all about 5 acres of storage space. The floors were designed to carry about 5 cwt. per sq. ft., exclusive of their own weight. The following method was adopted:—Two complete sets of centering for floors and columns were prepared for two lines of bays on each storey. The second floor or storey was thus two bays later than the lower in progress. Joints in the casting of floors were made over the centre of columns and main girders of each bay. Part of the lower storey walls were under earth pressure surcharged by traffic on the road adjoining. All these walls were cast in slabs and lifted by means of jacks and bolted into place into rebates specially cast in the wall columns and girders. The bays of floors are about 26 ft. by 15 ft. 6 in., measured centre to centre of columns. The columns are 16 in. square, with spirally wound reinforcement, and are based on foundation slabs 8 ft. square. The main beams for the 26 ft. spans are 20 in. deep from under-side of slab by 15 in. wide; secondary beams, 13 in. deep from underside of slab by 12 in. wide; the flooring slab is 5 in. thick. The walls are 9 in. thick where under earth pressure, and 4 in. thick for the rest of the work—these latter act only as curtain walls.

The roof is of concrete throughout, no frames or sashes for glazing being introduced. It is saw tooth in construction. There are six main girders constructed on bowstring type with the Pratt system of trussing; span 172 ft. centres. The top boom consists of a spirally wound member with 16 rods 1¼ in. in diameter at the centre, reducing to 16 ¾ in. rods at ends. The spirals are of No. 4 gauge bright steel wire. The upper boom is octagonal in shape, 22 in. across flats at the centre, reducing to 18 in. across flats at the ends. The bottom boom consists of flat steel plates—twelve 9 in. by ½ in. at centre, and two 10 in. by ½ in. at ends—placed on edge. They are fastened together with turned pins 1¼ in. in diameter, a driven fit. These plates were concreted, and the lower boom has the appearance of a concrete member. For the lower booms plates instead of rods were adopted, as the size of the lower boom would be much greater allowing for adhesion of concrete to the rods. The inclined members of the bowstring girders are ties, and the vertical are struts. The rods in the ties go round the steel pins in the bottom boom and round the rods in the top boom, the vertical struts are designed as spirally wound short columns. Each set of two bowstring girders is braced together for wind pressure by a spirally wound member with brackets connecting at each bay of the girder at the top boom. The saw tooth members were built in sections, the vertical member for holding the glass being an open girder, most of the load being taken up on the bottom member. The incline that forms the roof is composed of slabs of ⊓ shape. The slabs are approximately 18 ft. 6 in. by 2 ft., and are 2 in. thick. The gutter is formed in the lower end and cast with the slab.

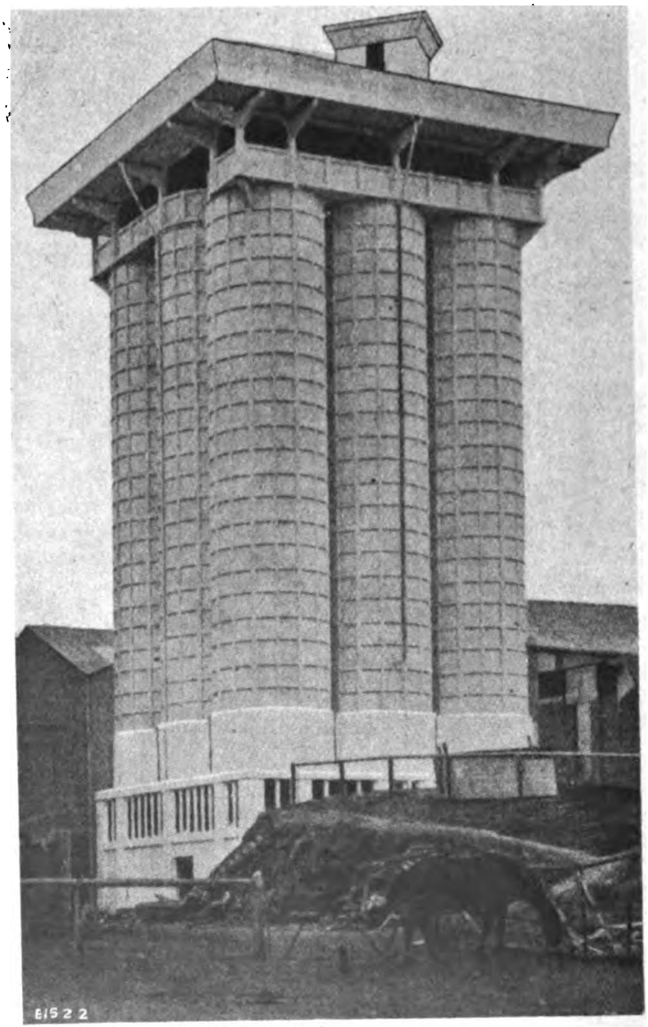


WOOL SHOW FLOOR, ALSO SHOWING CONCRETE ROOF.

[From the "Commonwealth Engineer."]

The method adopted for erection was to lift the vertical, or glass trusses, with winches into place, resting same on trestles at about the level of the lower boom of each bowstring girder. The roofing slabs were then lifted and butted close together, and bitumen and sand poured hot into the joints. These latter were of special design, and were first partially filled with cement grout, 2 of cement to 1 of sand. The bowstring girder was then cast in position, the reinforcement projecting from the glass trusses being cast into the vertical members of the girder. In designing the roof in this way no flashing was necessary for forming gutters or ridges, and the whole roof was sufficiently elastic for the constant changes due to temperature.

The movement in the main bowstring girders due to temperature was calculated to be ·80 of an inch, and provision was made at one end by a special mild steel carriage on case hardened steel rollers for sliding. Not as much movement as calculated has been noticed, the most being ·625 in. Provision to allow for this expansion at the ends had to be made, especially where the gutters joined the wall, but no difficulty has since been experienced by the methods adopted. A final camber of 2½ in. in the lower boom of the bowstring girders was allowed, so these were given a 5 in. camber during construction. When the supports were moved



From the "Commonwealth Engineer."]

WHEAT SILO.

the deflection was not quite 2½ in., thus the fixed camber remains at about 3 in. The water from the roof gutters is discharged into galvanised iron pipes which are built into the vertical columns forming part of the walls. No part of this building is of wood, except doors to sanitary premises and seats for same.

The concrete for floors, girders and columns, and roof slabs was mixed in proportion of four parts ¾ in. bluemetal, 2¼ parts local sand, and 1 part British Portland cement. The concrete for the main bowstring girder was mixed in proportions 3 parts ⅝ in. bluemetal, 1¾ sand to 1⅛ cement. All the aggregates of concrete were proportioned on lines of greatest density, stone dust being purposely added after exhaustive tests.

### WHEAT SILOS.

A number of wheat silos were erected at Melbourne for Messrs. James Minifie and Co., flour millers, and at Albury for Messrs. Burrows. These bins are 12 ft. dia., each ring consisting of 8 segmental slabs, 5 ft. high. The rails and styles of slabs are 5 in. thick, and the panels between 2½ in. The reinforcement projects as links or closed hooks beyond the ends of the slabs ; vertical rods go through each of the hooks, the horizontal joints being simply bolted together. The joints both vertical and horizontal, are filled by liquid grout poured vertically, which was found to fill every part of the joints. The bottom 8 ft. of the bins is solid, and the whole weight of the wheat and the structure is taken up by this as a circular girder, and distributed to four columns and then to foundation slabs. The circular girder is 8 in. thick. The bottoms are hoppered with a suitable slope for wheat.

The roofing of this structure is wholly of reinforced concrete. Projection is given to prevent rain from driving in, and is effective to as great an extent as desired. From the foundation to the top of the elevator the chamber is 108 ft. in height.

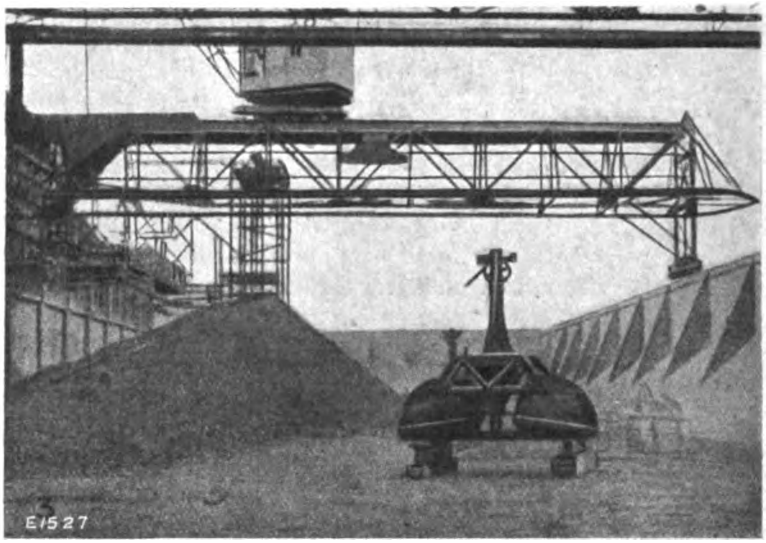
For the Melbourne silos, stone of broken bluemetal ¾ in. gauge was used ; for the Albury works granite sand was used throughout. British cement was used for the former and colonial for the latter. The walls of these bins are, the writer thinks, the thinnest used in reinforced concrete silo construction for wheat up to date.

### GAS WORKS AT MORTLAKE, N.S.W.

This is a very large scheme, comprising coal and coke bins, power station, telpher tunnels, retort houses, etc. The whole work is of reinforced concrete except a 4½ in. facing of brick.

There are many interesting features in this work. The telpher tunnels, for instance, were designed on the box system with contra-flexure stresses calculated in each member. The box was built with girders and slabs, the earth pressure being divided between them. A large coal store 400 ft. long by 128 ft. wide by 20 ft. deep was erected. The vertical concrete wall on the telpher tunnel side with the sloping hopper bottom is only 6 in. thick, with the buttresses every 16 ft. The traveller with grab full weighs in all about 108 tons, with a reaction load on this wall of 60 tons. The slab was calculated to act as a girder. This has proved satisfactory. The reinforced concrete portion of this work was designed by the writer, and carried out for him, under his occasional supervision, by Mr. Siddeley.

The generator station, consisting of engine-room, boiler-house, and coal hoppers, is considered to be interesting. The roof is of reinforced concrete built in situ with triangular trusses, purlins and slabs ; the top side of slab is tarred. The floor of the engine-room carries direct steam-driven electric generators, and is 12 in. thick, built on columns over a basement in which the steam condensers are placed. Engineers were of the opinion that the floor would vibrate, and in time disintegrate. However, a penny can be placed on edge on the base plate of the engines without falling.



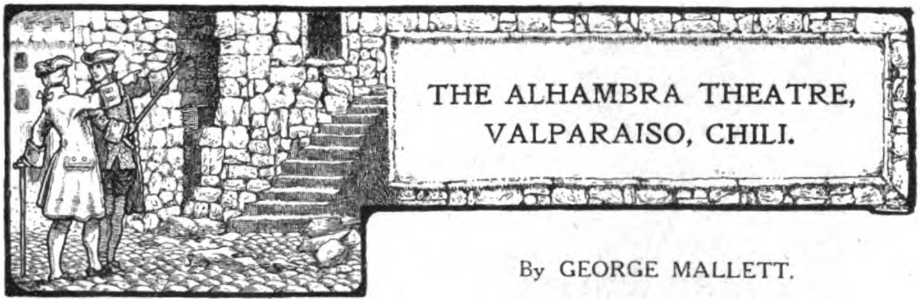
COAL STORE AT THE GAS WORKS, MORTLAKE, N.S.W., SHOWING VERTICAL CONCRETE WALL ON THE RIGHT, 6 INS. THICK.

### PONTOONS FOR SYDNEY HARBOUR TRUST.

Two pontoons, one of 750 tons displacement and the other of 1,000 tons, were constructed for the Sydney Harbour Trust to act as landing stages for passengers arriving by certain ferry boats at Circular Quay and at North Shore. Boats arrive and depart from each side of the pontoons and the principal stresses encountered are those met with in launching, the compressive stresses between two berthing vessels, the deck load due to a crowd of people estimated at 100 lb. per sq. ft., and the resultant water pressure. The reinforcement of the 1,000 tons pontoon is interesting. The cross girders or deck and floor beams are designed to act at the same time as girders and columns, so that the rods can act in bending for the floor loads, and in compression for that occasion which sometimes occurs when two ships berth together. Spirally wound girders were used.

A similar pontoon, but a little smaller, was built for the same trust for the North Sydney ferry, North Shore. The department has expressed its satisfaction with both these floating structures.

*(To be concluded.)*



# THE ALHAMBRA THEATRE, VALPARAISO, CHILI.

By GEORGE MALLETT.

THE "Teatro Alhambra," in the Avenida Pedro Montt, Valparaiso, arose, like Phœnix, from the ashes of the "Teatro Valparaiso," which occupied this site up to 1914, when it was totally destroyed by fire.

The Franco-Chileno Insurance Company acquired the site in 1916, and, after a careful study of a variety of schemes for the erection of a rentable property, the idea of a modern cinematograph theatre was ultimately adopted, and the work entrusted to the company's architect, Mr. O. L. Mac-Dermott, of Valparaiso.

The site contains some 6,500 sq. ft., with a frontage to the Avenida Pedro Montt of 76 ft., and separated from its next-door neighbour, the "Teatro Colon," by a 7 ft. 6 in. passage.

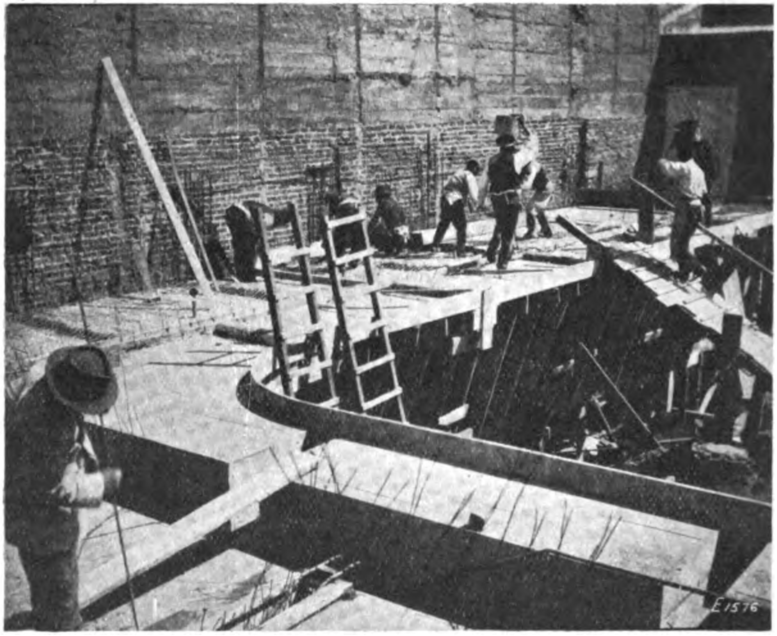
At this time the new theatre by-laws of the Valparaiso Municipal Council had just come into force, by which the public were safeguarded from personal danger by fires, panics, lack of proper sanitation, etc. This ensured for the Alhambra the most up-to-date improvements.

Official permit to build was given in July, 1916, and operations were commenced some days later. Ten months afterwards, in May, 1917, the theatre was opened to the public.

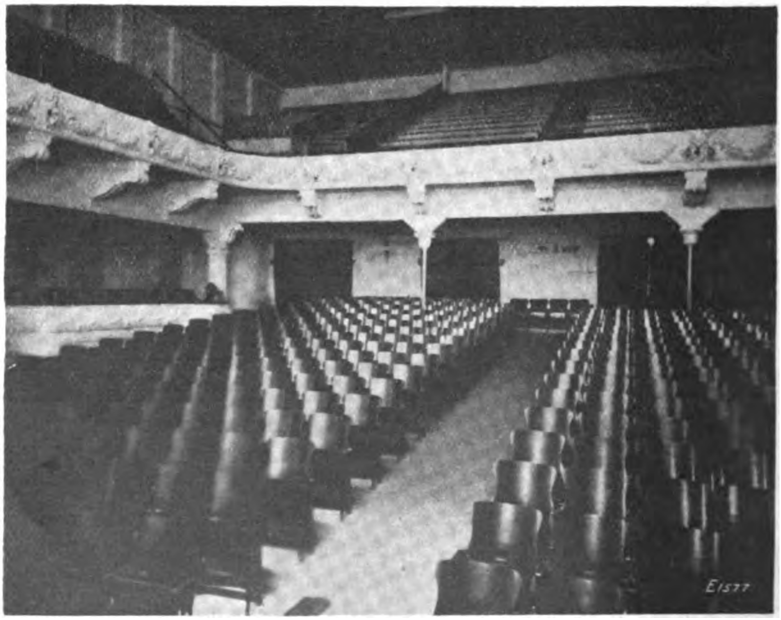
The new by-laws prohibit the use of timber in the construction of theatres, except for doors, windows and minor fittings, and, in view of the great number of similar buildings destroyed by fire, the use of non-combustible material is insisted upon. As brickwork is too unreliable in an earthquake country like Chili, the choice lay between a steel-frame and reinforced concrete building. A comparative study of the two systems proved reinforced concrete to be the most economical, in addition to the superior element of safety against fire and earthquakes.

This material was accordingly adopted, there being no steel beams or joists used in the building, which is reinforced concrete throughout, the reinforcement being of round bars and B.R.C. steel-wire fabric. In the case of the iron columns, however, which support the gallery, at the entrance to the pit, 3½ in. round columns were chosen, so as not unduly to interrupt the view of the stage.

The land in this part of the city is principally foreshore reclaimed from the sea and filled in from time to time. The old foundations of the Teatro Valparaiso were, however, found to be perfectly sound, and consequently were utilised for the main walls of the new edifice, except in a part of the main frontage to the Avenida, where it was found necessary to strengthen it. The foundations in all



Balcony in course of Construction.



Pit showing Side Boxes and Balcony.

cases rest upon hard sand, at a uniform depth of 12 ft., and are of concrete, made of one part Portland cement, three parts of clean sand, and six parts of broken granite.

*Arrangement.*—The Pit, with side Boxes, occupies a space of 73 ft. square, and is entered from a spacious vestibule or Foyer, 47 ft. by 20 ft. The Foyer also contains the ticket office and men's cloak rooms, which occupy the space under the stairs leading to the Balcony and Gallery, leaving the whole of the Foyer floor space clear. The ladies' cloakrooms occupy a place inside, at the entrance to the Boxes, on the east side of the theatre. On this side there are three large emergency doors opening into the outer passage between the two theatres; and on the opposite, or west side, the alley-way leading to the Boxes has been extended to the street, to form an additional exit. The exit doors from the Foyer are 31 ft. wide, and the emergency doors 23 ft.

The Balcony and Gallery are situated over the Foyer, projecting 14 ft. over the back of the Pit. This section occupies the full width of the building and has a seating capacity of 528 persons. It is approached by means of two stairways, each one over 16 ft. wide. At the back of the theatre there is a small anteroom and yard for the use of the orchestra, etc. The Pit contains accommodation for 425 persons, and there are 8 Boxes.

*Construction.*—The wall of the Façade up to the level of the Gallery is 20 in. in thickness. Over the entrance doorways this wall is reinforced with ¾-in. steel bars, forming beams. From the level of the Gallery floor the wall of the Façade is reduced to a thickness of 4 in. only, but this is strengthened with pilasters equal in thickness to the wall.

The lateral walls are built with pillars, 20 in. by 10 in., at a distance of 8 ft. 4 in. between centres. These pillars are reinforced with six vertical ¾-in. bars and $\frac{3}{16}$-in. wire hoops, 8 in. apart. Between the pillars the walls are 6 in. thick up to the height of the Gallery floor, and 4 in. from there upwards, and reinforced as follows :—Horizontal bars, ½ in. in dia., are fixed between the pillars, at a distance of 5 ft. apart, and to these bars is fastened B.R.C. steel-wire fabric No. 14, by means of ⅛-in. wire. The remaining exterior walls are built in the same way, and also the interior walls of lavatories, etc.

The floors are calculated to carry a live weight of 90 lb. to the square foot, with a safety coefficient of 4. The floor-slab in general gives a greater coefficient, as the thickness of the slab, 6 in., is calculated for the maximum span, and it was considered unwise to reduce this in the smaller spans. The whole of the floor slabs are reinforced.

The largest beams are those which carry the lateral sides of the Gallery. These beams have a span of 25 ft. and are 30 in. deep by 12 in. thick. The reinforcement consists of six ⅞-in. bars, with ¼in. wire stirrups arranged in the usual way. The dimensions and reinforcements of the other beams are calculated in each case in accordance with the maximum load which could be imposed. There are a considerable number of beams of different types.

The columns in the line of the Boxes which carry the beams of the lateral sides of the Gallery are 8 in. by 8 in., and reinforced with six vertical ¾-in. bars and ¼-in. horizontal hoops, 8 in. apart.

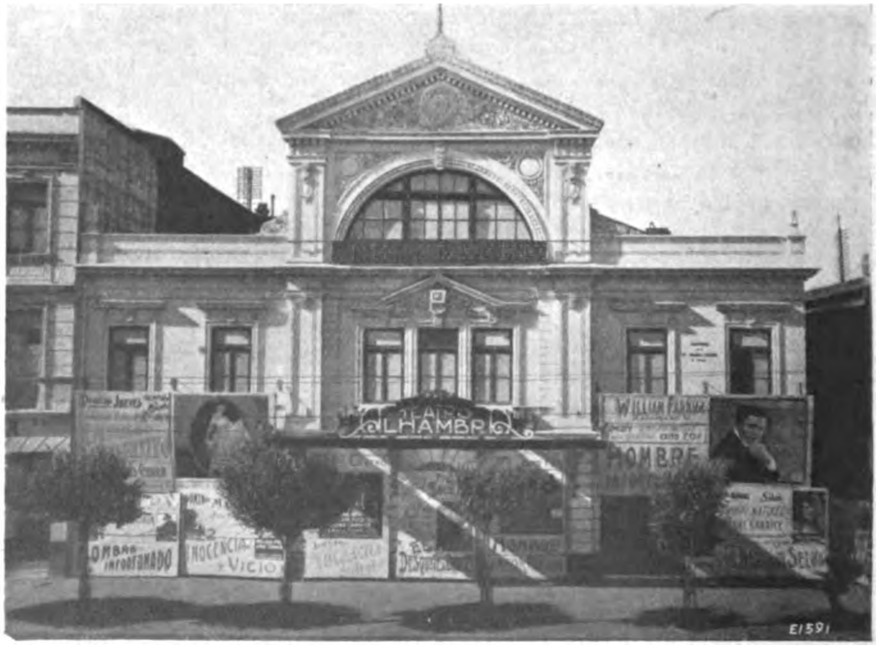
The cinema projection-chamber is constructed with 6-in. walls, reinforced similar to the rest and extended upwards under the steps of the Gallery to the front wall of the building, where it terminates with an iron grating. This secures complete isolation from the rest of the theatre, together with ample ventilation and, in case of fire, the smoke and flames go direct outside the building without being seen by the audience in the theatre. The doors of this chamber are of iron.

The roof of the building consists of iron principal-rafters embracing the whole span of 75 feet. These principals are fixed 11 ft. 6 in. apart, and although of an economical construction are very strong. Each principal weighs about 3,000 lb. and averages 75 ft. long. Horizontal stretchers of channel iron connect these and run the whole length of the building at convenient intervals to support the galvanised corrugated iron roofing.

The ceiling of the theatre, as also the Foyer, is composed of stamped metal sheets fixed to wood battens. Six large ventilators are provided with sashes to open and shut from the amphitheatre. There is also a large lantern with revolving roof, which opens automatically in case of the cords getting burnt.

The view-screen is finished in plaster of paris directly on the wall and at the required height to avoid the rays being intercepted by persons standing in the main aisle: while the projection chamber is also calculated to secure an uninterrupted horizontal projection.

The floor has a slope of 1 in 13, and the seats are automatic, of the type approved by the by-laws. The steps and floor of the Balcony and Gallery are of wood, resting upon the reinforced concrete floor.



View of Finished Building.

# THE ECONOMICAL DESIGN OF REINFORCED CONCRETE FOUNDATION SLABS.

By CHARLES S. HIGGINS, B.Sc., A.M. Inst. C.E.

*In the article which we publish below the writer does not mention that his example of 200 T stanchion on 3 ft. square base gives a pressure of concrete of 22·2 tons per square foot—the maximum allowed by the London County Council is 12. This consideration often necessitates some form of grill. The shape and arrangement of reinforcing rods suggested can be much improved, but the main contention is correct.—ED.*

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When the low bearing capacity of certain soils has necessitated the use of reinforced concrete foundations which distribute the load over a large area, it has hitherto been the practice to design a type of beam grillage to meet the required conditions.

The high cost of steel at the present day, however, calls for an investigation of the usual grillage design, with a view to reducing the quantity of steel used, and, at the same time, to arrange a section which shall make the fullest use of the properties of both steel and concrete, while yet being sufficiently strong as to meet all possible requirements.

Let us first of all consider the quantity of steel used in the construction of a standard beam grillage for a stanchion. The example quoted is taken from Messrs. Redpath, Brown and Co.'s Handbook of Structural Steelwork. A three tier grillage is arranged for (*Fig.* 1)

The amount of steel here used is found to be (from standard tables).

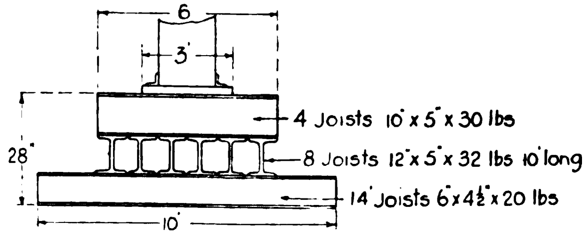
Top tier 24 × 30 ft. = 720 lbs.
Middle tier 32 × 80 ft. = 2,560 lbs.
Bottom tier 140 × 20 ft. = 6,000 lbs.

Total 9,280 lbs.

It seems of great importance that this quantity of steel should be considerably reduced.

In the calculation of the economical foundation slab the same essentials are accepted—*i.e.*, the area of soil covered is 100 sq. ft. and the concrete base is 10 ft. by 10 in., while the size of the stanchion base is 3 ft. by 3 ft. Total load on stanchion = 200 T.

FIG. I


6
3'
4 Joists 10" x 5" x 30 lbs
28"
8 Joists 12" x 5" x 32 lbs 10' long
14' Joists 6" x 4½" x 20 lbs
10'

The following notation is used.

$n$ =depth of neutral axis from top of concrete.

$m$ =ratio of the section modulus of the steel in tension ($E_t$) to the section modulus of the concrete in compression ($E_c$), a common value for $\frac{E_t}{E_c}$ being 15, which is here adopted.

$\gamma$ =ratio of the safe working stress of the steel ($t$) to that of the concrete ($c$),

$h$ =total depth of concrete.

$d$ =the effective depth—*i.e.*, from the top of the concrete to the centre-line of the steel, and usually taken as $h-2$ in.

$A_t$ =cross-sectional area of the steel.

(1) Calculation of depth of concrete required.

This will be determined by the depth of concrete necessary to resist shear along the section *XX*.

Shaded area (*Fig.* 2)$=35$ sq. ft.

Shearing force$=\frac{35}{100}\times 200\ \text{T}=70$ tons.

Taking a safe working stress for concrete as 50 lbs./in.$^2$ $70\times 2{,}240=120\times 50\times h$.

$\therefore h=7\times\frac{224}{60}=26{\cdot}13$ in., or say 2 ft. 6 in. of concrete.

$\therefore$ effective depth $d=h-2$ in.$=28$ in.

(2) To find the position of the neutral axis $N\,N$ (*Fig.* 3). Take $t=16{,}000$ lbs./ft.$^2$ and $C=600$ lbs./ft.$^2$ as above.

FIG. II

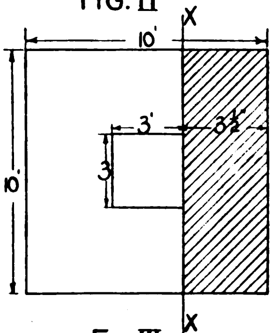


FIG III

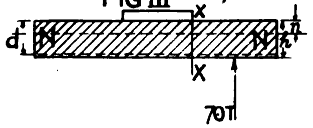
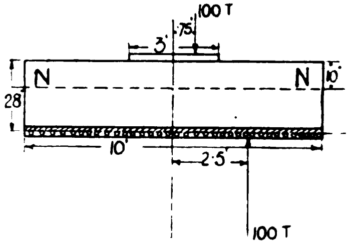


FIG. IV



$$\frac{n}{d}=\frac{m}{\gamma+m}=\frac{15}{\left(\frac{16{,}000}{600}+15\right)}=\frac{15\times 600}{25{,}000}=\frac{9}{25}$$

$$\therefore\quad n=\frac{9}{25}\times 28=10{\cdot}08\text{ in.}$$

or say $\underline{\text{10 in.}}$

(3) To find the amount of steel required :—

$$A_t\times t=\frac{C}{2}bn$$

$$\therefore\quad A_t=\frac{300\times 120\times 10}{16{,}000}=22{\cdot}5\text{ sq. in.}$$

which is equivalent to 2¼ sq. in. per ft. (each way).

The cross sectional area of ¾ in. rods$={\cdot}442$ sq. in.

Use then, say, 5 rods per foot.

*Weight of this quantity of steel.*

If the bars be assumed 10 ft. long, and are 100 in number, 1,000 ft. at 1·502 lb per foot=1,502 lbs.

(4) The concrete slab must now be tested as a beam (*Fig.* 4) to determine the moment of resistance of the concrete, and whether the compressive stresses induced in the concrete by the loading are within the safe working limit.

Maximum bending moment:—

$$\begin{aligned} &= 100\text{ T}\times 2{\cdot}5 - 100\times{\cdot}75\\ &= 100\times 1{\cdot}75\\ &= 175\text{ tons feet.}\\ &= 2{,}100\text{ tons in.}\end{aligned}$$

Using a well-known formula, 2,100 tons in. $=\frac{C}{2}bn\left(d-\frac{n}{3}\right)=$ moment of resistance of slab.

$$\therefore\quad 2{,}100\times 2{,}240=\frac{C}{2}\times 120\times 10\left(28-\frac{10}{3}\right)$$

$$\therefore\quad C=\frac{42}{4\times 74}\times 2{,}240=\underline{318\text{ lbs./in.}^2}$$

This value, it will be seen, is far below the allowable compressive stress for the concrete.

(5) The slab may be further considered as a compound beam, and from drawing its bending moment diagram it can be seen that the steel bars selected above can be shortened.

FIG. V

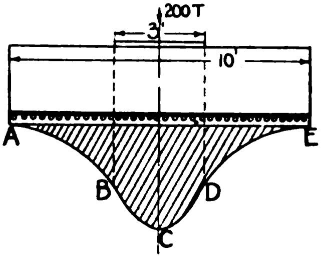
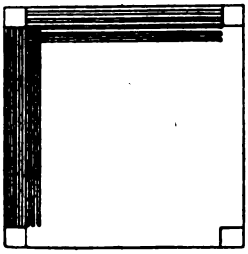


FIG. VI



The hatched-in area *ABCDE* will be recognised as the bending moment diagram for the beam carrying the 200 T central loading on the 3 ft. square stanchion base. *AB* and *ED* are parabolic curves with apices at *A* and *E*, *BCD* a parabola with apex at *C*.

It will be seen that as the ends *A* and *E* are approached, the bending moment becomes very slight, and for at least 1 ft. from the ends of the beam is practically negligible. Hence the rods may be shortened by a foot at each end, making them 8 ft. in length, and effecting a further saving in the weight of steel used.

As may be seen from the uncompleted diagram (*Fig.* 6) only a foot at each end of the slab is left in single reinforcement, and one sq. ft. at each corner unreinforced, which can be safely done.

The weight of steel used will now be 100 × 8 × 1·502 = 1,201·6 lbs.

The advantages in the use of economical concrete slabs over the ordinary grillage foundations then are

(*a*) the enormous saving in the quantity of steel used (*i.e.*, 9,280 − 1,201·6 = 8,078·4 lbs. on 9,280 lbs. or approximately 87 per cent.). It will readily be realised how important this is when the cost of steel reaches so fanciful a figure as £50 per ton.

(*b*) Since as was shown in paragraph (4) the compressive stress in the concrete here = 318 lbs./in.², for a slab of this depth an inferior mixture (say 1 : 3 : 6) might be safely used, further reducing the expense.

Alternatively the depth of the beam might be reduced, still keeping the compressive stresses within the 600 lb./in.² limit, thus reducing the excavation necessary.

The ferro-concrete slab may without doubt be further improved upon, but the above reasons should seem sufficient for its serious consideration by practical men.

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The author states, in response to our Editorial Comment at the beginning of this article, that the L.C.C. requirement of 12 tons per sq. ft. can be overcome by increasing the bearing plates to some suitable size—say 4 ft. by 4 ft. 6 ins.—ED.

# THE USE OF CONCRETE IN THE NETHERLANDS.

By A. E. DINGER,
*Chief Constructional Engineer of Mines in the State of Limbourg.*

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THE ability of reinforced concrete to resist tensile and shearing stress, its property of cracking long before it collapses—thus showing that the limit of safety has been passed before serious risk of danger need be run—has made this material of great value in mining. Indeed, it is an astonishing proof of its value shown in the fact that, notwithstanding the unfavourable conditions in the years 1914-1919, more than £100,000 worth of reinforced concrete was used in the mines in the Netherlands. Amongst other work, two structures relative to the Wilhelmina State Mine are of special interest.

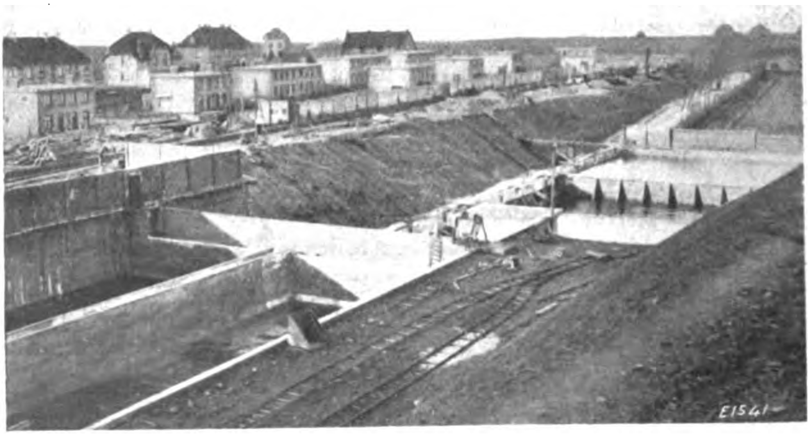


Fig. 1. South View of the whole Installation.

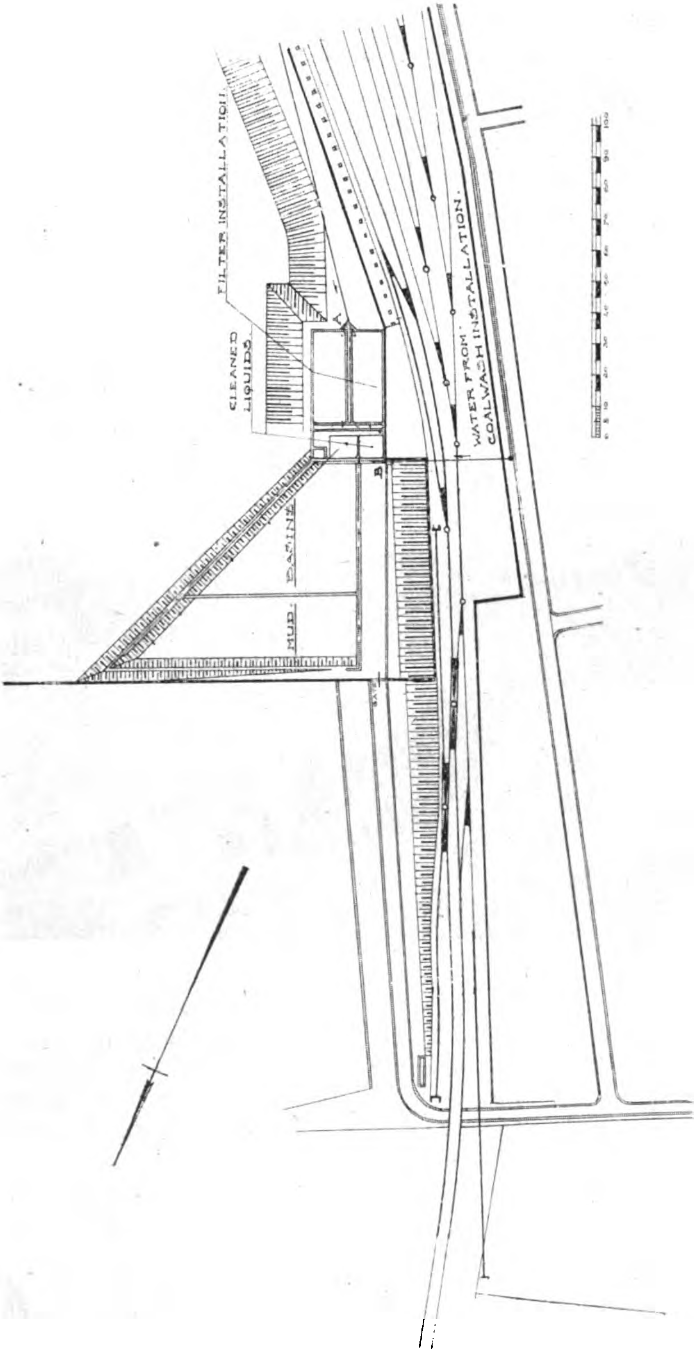


FIG. 2. WATER CLARIFYING INSTALLATION, WILHELMINA STATE MINE.

*Clarifying and Sedimentation Tanks.*—The installation shown in *Figs.* 1-3 consists of two systems which discharge into a common tank, the clarified water being pumped into a water-course some distance away. In the system on the right, the water supply for the buildings and service of the mine and for a number of houses is clarified by decantations and filtration. There is very little suspended matter in this water and clarification is only needed during or immediately after a heavy rainfall. A channel between the two tanks carries off any surplus storm water, without purifying it. The water enters the clarifying plant at A, passing first the sluices, then the coarse grids, and finally enters the filter-tank, through which it flows, at a speed of 1·4 in. per hour, into a channel which directs it into a second tank or reservoir, from which it is pumped as required.

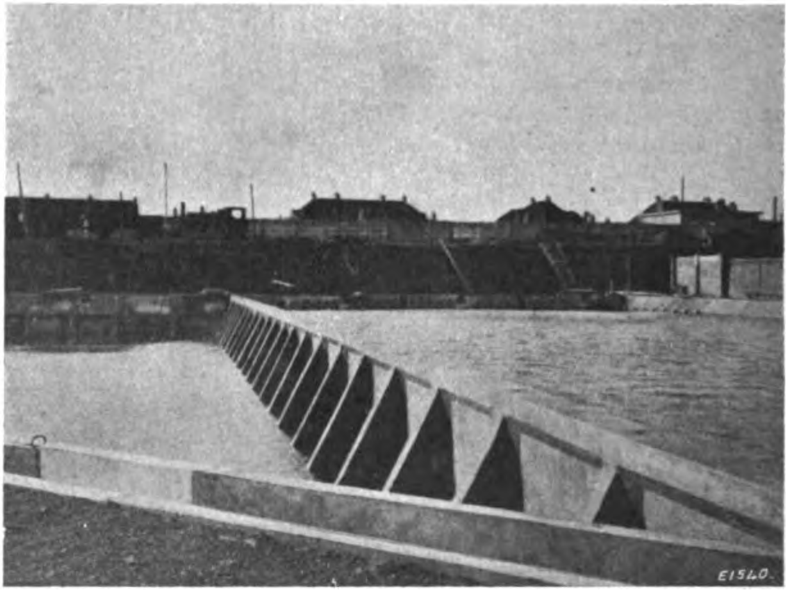


FIG. 3. EAST VIEW OF MUD BASINS.

The water discharged from the coal washers passes through a sewer under the railway. This water is polluted by fine coal-dust and clay and contains 2·75 per cent. of solid matter. It flows along two sides of the reservoir, and then along the north wall of the settling tanks. Sluices are provided whereby the wash water can be taken to either of the two mud tanks. The water flows through these tanks at the rate of 6 in. per hour and is discharged into a channel which, passing below the first channel, carries the water to the two other tanks, from which it is pumped to the washers for further use. The discharged effluent contains only 0·02 per cent. of solid matter.

The deposited sludge in the tanks used for clarifying the water supply for the mines and houses is removed through narrow channels, which are mounted on wooden horses at each clearing of the tank and discharge their contents into wagons. The sludge from the coal washers is removed by horses and carts,

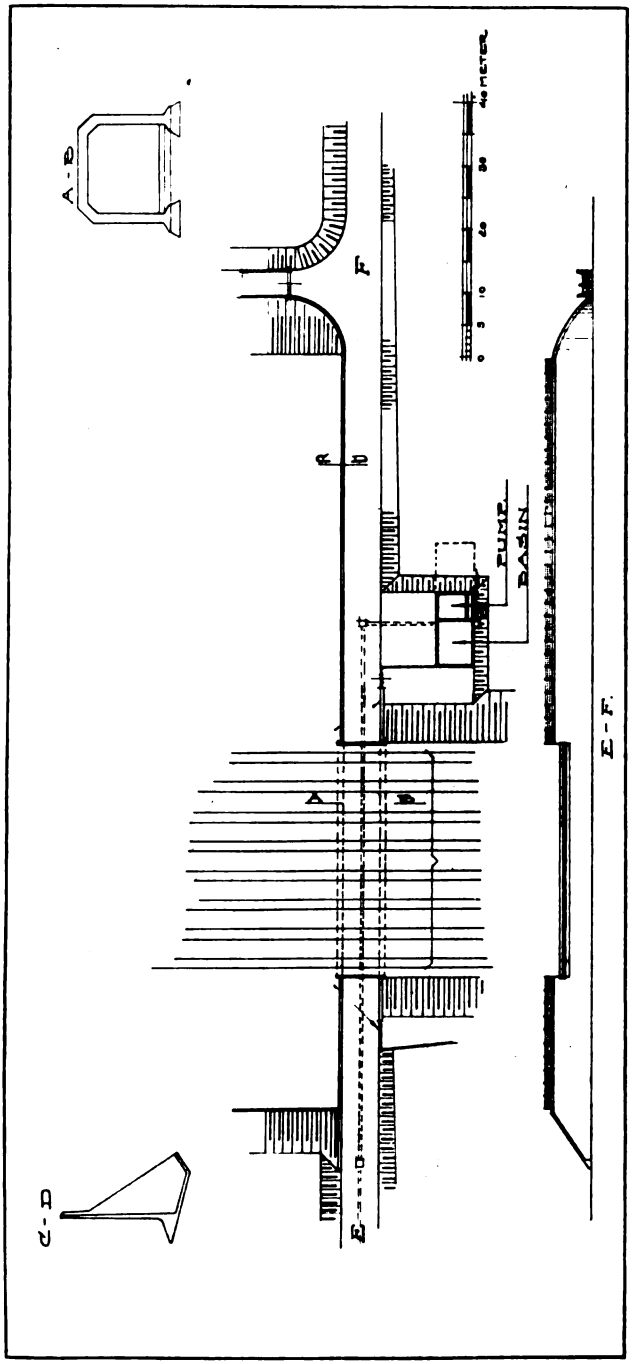


FIG. 4. PLAN OF BRIDGE AND STREYTHAGEN ROAD.

which can enter the tanks after a sluice-gate made for the purpose has been opened. The cakes of damp coal dust are readily sold to the owners of the horses and carts. Sludge which is too fluid to be removed in any other way is pumped out.

*A bridge on the Streythagen Road.* which is regarded locally as a work of art, consists of a tunnel 15 ft. high, 18 ft. wide, and 123 ft. long internally. The lateral walls are coupled to the roadway or table of the bridge by suitable tie-beams. The side walls—16-22 ft. high—are built as retaining walls and provided with an inclined support (C, D, *Fig.* 4), the free extremity of which has a re-entrant angle of 60°. The buttresses are 6 ft. apart. In order to gain some idea of the forces to be resisted it is necessary to remember that the horizontal reaction on the retaining walls is 25 tons per square yard, or the equivalent of 3,000 tons of horizontal pressure on the whole of the retaining wall.

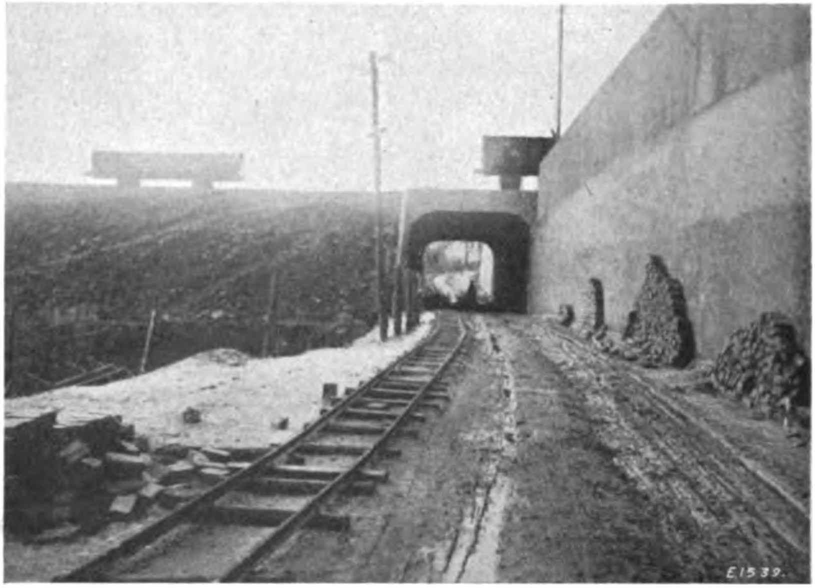
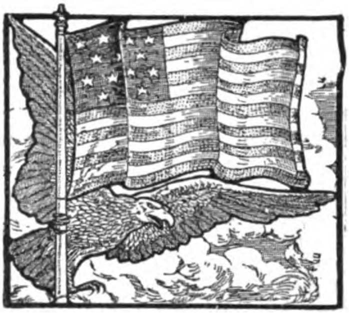


FIG. 5. VIEW THROUGH THE VIADUCT.

The roadway or table has been designed to receive a continuous layer of ballast, so as to permit the greatest possible replacement of the rails, and the bridge is designed to carry locomotives weighing 90 tons, or 18 tons per axle. The greatest moment realised in the body of the bridge is 16 tons per square yard in the direction of the viaduct.

In order to obtain sufficient height below the bridge, the level of the Streythagen road has been lowered, necessitating the installation of a catch-pit and an electric pump to remove any water which would otherwise accumulate. The work was executed by G. Kuypers, of Rotterdam.

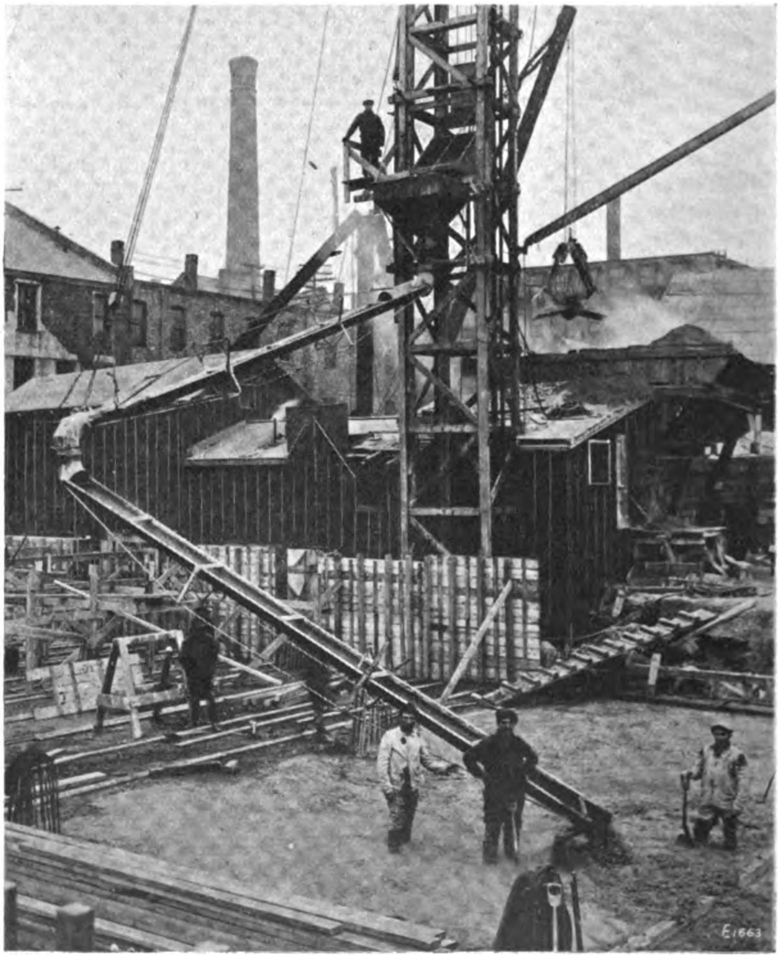


# A
# CIVIL ENGINEER'S IMPRESSION OF AMERICA.

THE opinion very frequently heard in England that English methods of to-day are those followed in the United States five or ten years ago seems to be particularly true when applied to the large field of construction engineering. This does not by any means indicate that English methods are " behindhand " to this extent, but rather that conditions in America have imperatively forced on their engineers' ideas, and machines to carry out their ideas, a considerable time before exerting a similar pressure on this side of the Atlantic. These compelling conditions can be summed up in one word, "labour," and it is to the cost, scarcity and quality of the commodity coming under this heading that to-day's constructional methods in the United States are due. Even if it was desirable, which is doubtful, it is extremely improbable that labour in England will ever return to its previous cost relative to other commodities, and for this reason a short description of some of the methods almost universally adopted in the States may be of interest. That these methods should be adopted as being always the best for English conditions is not for a moment suggested ; but that English contractors can profit by using some American methods (and sometimes machines) is undeniable—a glance at the equipment and operations of the most up-to-date firms doing work in London and the Provinces shows how the wind sets.

One of the commonest sights which strikes the eye of a visitor to any growing city or industrial area in America is the number of steel or wooden towers which form part of the concrete-placing equipment used by nearly every contractor on concrete work. The almost universal method of placing concrete, even on small jobs of, say, 1,000 cu. yd., is by the "chute" method. In this method the concrete mixer is placed at the foot of a steel or wooden tower which is built up to well above the height of the completed building. The mixer dumps its concrete directly into the " tower bucket," which is of any capacity from one-half cu. yd. up ; the bucket is raised by a hoist and automatically caused to dump into a " tower hopper " fixed to a frame sliding on the outer face of the tower ; from the tower hopper the concrete runs by gravity down sloping metal chutes (usually open and set to a slope of about 1 : 3), and is led straight into the forms or shuttering. Or, if more convenient, is led into a receiving hopper and from there wheeled a very short distance to where required.

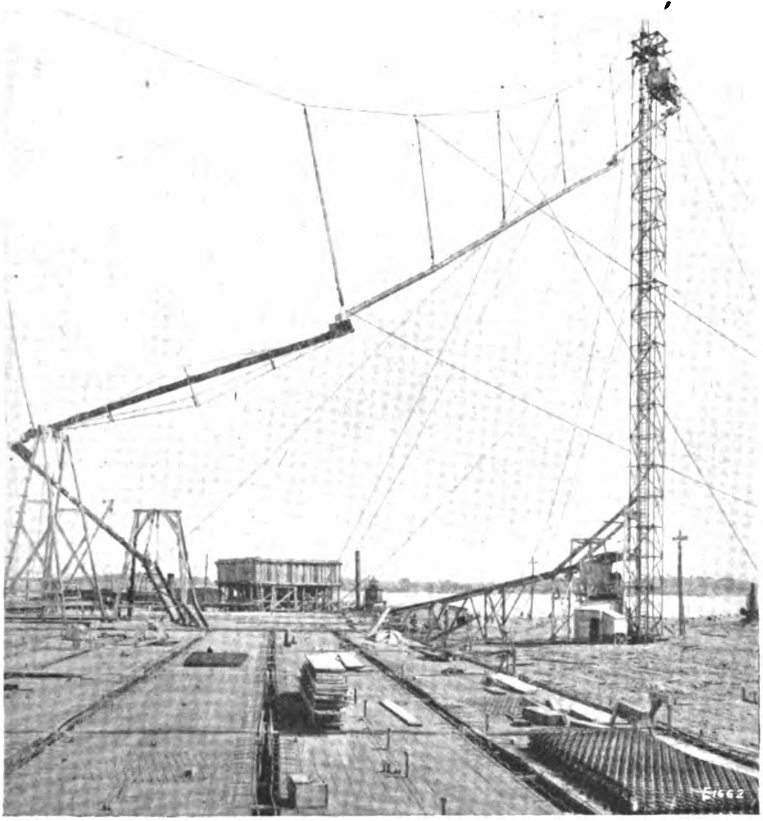
The small amount of labour required to operate a plant of this kind is most striking. From the mixer to the shuttering, three to five men (including the hoist driver and fireman) are all that are necessary to place concrete at the rate of forty-five batches every hour. Various ingenious methods of supporting the chutes are used ; where the concrete is to be conveyed a long distance, say 300 or 500 ft., as is often the case, the chutes are usually suspended from a steel cable strung from the top of the tower to some convenient anchor on a neighbouring building or to another tower. When the distance is short, say 150 ft. only, an ingenious counterweight chute system is very commonly seen, enabling the entire chuting system to be self-supporting from its own tower. (A glance at the accompanying photographs make both these systems clear). In both cases, when the progress of the work reduces the slope of the chutes to less than the working limit, the sliding frame



Wood Tower and Trussed Chute.

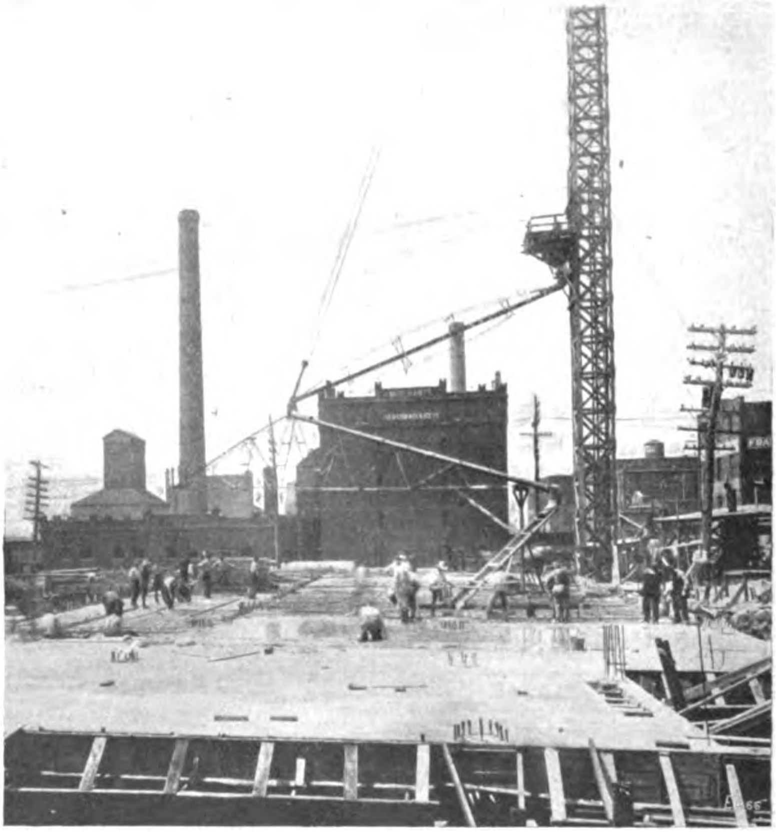
on the face of the tower carrying the tower hopper, and with it the upper end of the chute, is bodily raised by tackle 15 ft. or so up the tower to a new position, the whole operation taking a very short time. Where it is desired to place concrete in two widely separated portions of the work from the same tower, two lines of chuting can be led off from the tower hopper, the concrete being guided into either at will by a two-way switch.

The prejudice against concrete placed in this way seems to have completely disappeared in America, and it is now a standard method with firms having the highest reputation for sound work. It is indeed argued as a point in its favour that the concrete in turning over and over while in the chute increases the thoroughness of the mix. The steel chutes, tower buckets and hoppers are treated by contractors as part of their general equipment, in the same way as are their mixers, hoists, etc. The concrete can be placed by this means fairly " dry " or at any rate as dry as is feasible for use in roof or wall slabs. If the chutes are at the correct slope, there is no tendency for the concrete to " separate out," for the heavy aggregate to run away from the mortar. The chutes and tower equipment are usually obtained from firms who make a speciality of these products, contractors having found from experience that " home-made " chutes and hoppers have to be more carefully " engineered " and constructed than might at first appear. A concrete-placing equipment such as I have described, having, say, a radius of 150 ft., and including tower equipment and chutes, could be obtained in England for about £800, and would have a life of about 20,000 to 30,000 cu. yd. of concrete.



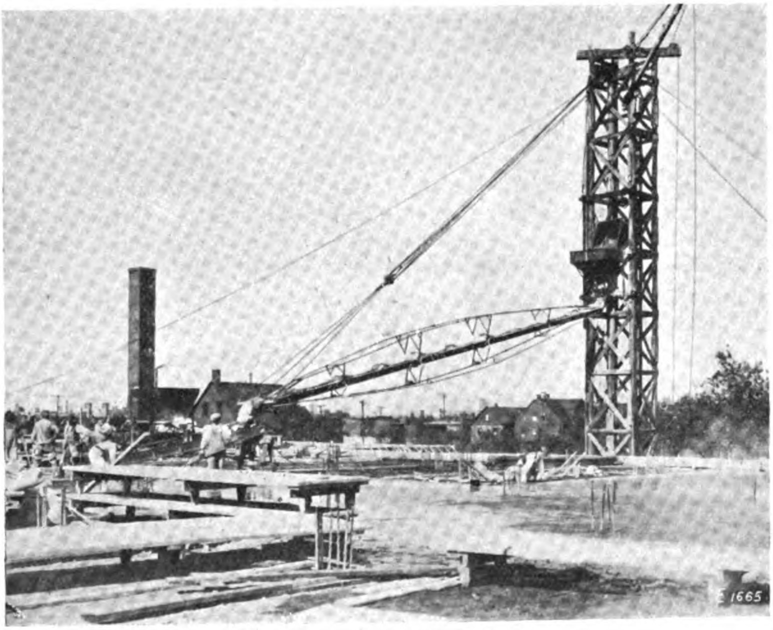
STEEL TOWER AND LINE CHUTING LAYOUT.

Just as the above-described method of " placing " concrete seems to be becoming standard practice in America, so also the handling of the cement and aggregate seems to be "standardizing" itself. Contractors realize that in these days of uncertain and intermittent deliveries of material, it is vitally important to have facilities for amassing a large quantity of material (sand, stone and cement), and for efficiently rehandling this material when necessary. Few contractors fail to lay out their equipment so as to deal economically with the ordinary daily or normal deliveries, but in many cases money is dropped either by lack of sufficient reserve storage or lack of provision of means for dealing with it. Deliveries have lately been so irregular that contractors often decline to commence work until they have a big proportion of the whole amount of their aggregate, etc., on the site.

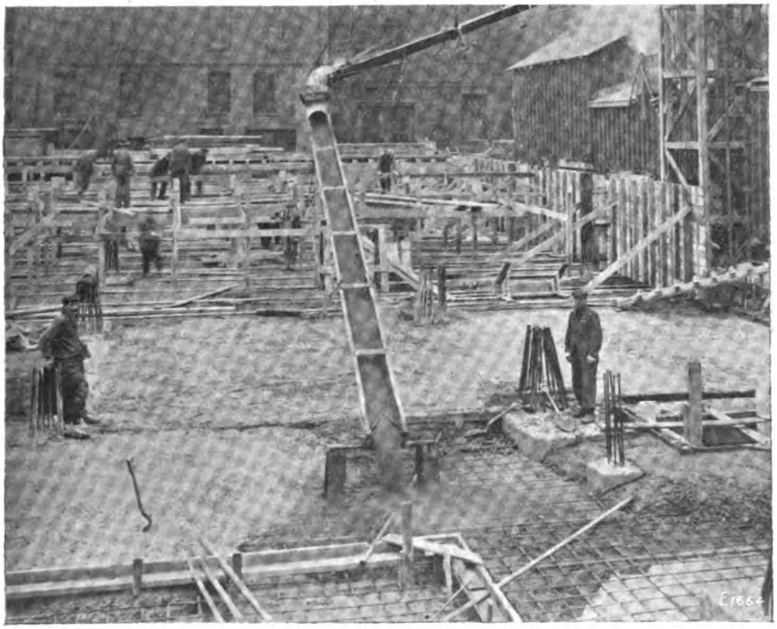


WOOD TOWER AND COUNTER-WEIGHT CHUTE.

The method most frequently seen of handling this problem is by the stiff-leg derrick and clam shell bucket. If delivery is by lorry or cart, the material is simply dumped on to the ground, picked up by the clam shell and dropped into the mixer bins. When these are full the material is piled up into a stock pile from which, when required, the bins can be replenished. This method has great capacity and flexibility. Most of the similar types of American steam shovels, such as the Thew or Osgood, are made so that, by a simple addition of an extra drum and plain boom, a clam shell bucket can be handled, and the shovel is often so used after the excavation work is completed.



Wood Tower and Trussed Chute.



Chuting into Floor Slabs.

Portable belt conveyors or gravity conveyors are often used to store the cement and to convey the bags from storage to mixer platform, the mixer usually being driven by steam from the hoist engine boiler.

The writer was fortunate in coming into contact with one of the largest companies manufacturing concrete-placing equipment (The Lakewood Engineering Company), and he had an opportunity of seeing something of their methods. They believe, and practise the belief, that if they sell *methods*, the rest will look after itself. They practise this by maintaining a force of "installation engineers," which is quite apart from the sales force. These men have all had considerable construction experience, and they put this experience at the disposal of contractors and engineers who wish to study the most economical layout for any special job in view. This company has established such a reputation for fair and disinterested advice that they are constantly being called upon to assist in construction layouts, since contractors realize that their work puts them in contact with a wider variety of jobs than normally falls to any one contractor.

The company, on the other hand, even where none of their equipment can be recommended, gains from the added experience afforded to its engineer: in short, the company does not "peddle machinery" but "sells methods."

A. S. C. Trench.

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## MEMORANDA.

**Soaking Concrete in Magnesium Fluosilicate and Sodium Silicate.**—Some tests by the Bureau of Standards, Washington, seem to indicate that a rich concrete may be improved in strength by soaking it for certain periods in magnesium fluosilicate ($MgSiF_6$) and sodium silicate ($Na_2Si_4O_9$), but the amount of water absorption is thereby increased. The results given are based on a limited number of experiments and cannot be considered as conclusive, but rather as a preliminary study to indicate prospective lines for more extensive research. Part of the specimens were cured in the usual way, and some for different periods in solutions of magnesium fluosilicate and sodium silicate. Tests were made with 2 in. cubes, the aggregate being Potomac sand and gravel, and the proportions were 1 : 1 : 2 and 1 : 2 : 4. The solutions in which the specimens were stored were maintained at approximately 4 per cent. by adding water from day to day to compensate for evaporation. The summary of the investigations is as follows:—

The tests indicate that the 1 : 1 : 2 concrete cured in $MgSiF_6$ solutions was improved in strength for three out of the four different curing conditions. The same concrete gave appreciably higher absorption values for two curing conditions, and was practically unaffected by the other two conditions. The 1 : 2 : 4 concrete showed no appreciable change in strength for any of the curing conditions in $MgSiF_6$ solutions, but a slightly higher absorption in all other cases.

The 1 : 2 : 4 concrete cured for various lengths of time in sodium silicate solutions gave slightly higher strengths and slightly lower absorptive values for all the different conditions.

**A New Fire-Resisting Sheathing and Insulator.**—Porete is the name of a new fire-resisting building material made in America in slab form as a sheathing material, and base for stucco as a sheathing on steel-frame buildings, for fire-stops, roof-decks and inside furring. Porete is said to be made of Portland cement and sand only; it has the appearance of pumice, excepting only that the bubble-holes are larger, somewhat like a rubber sponge. It is not announced how the porous characteristics are obtained, but the original mixture of sand and cement is said to contain some other material which, after partial curing of the concrete, become gaseous under the application of heat, and passes off leaving the holes. The material is made in thin slabs for the different purposes mentioned, and at 1 in. thick weighs only 5 lb. per sq. ft.—*Concrete, U.S.A.*

# A SWEDISH CONCRETE BRIDGE.

*We are indebted to Mr. Hiort Lorenzen, Engineer on the Danish State Railways, for the following particulars and illustrations.—ED.*

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ESPECIAL interest attaches to a railway bridge over the valley of the Ore because its main arch is no less than 93 ft. high and 307 ft. between the abutments, and so is one of the largest spans ever built in reinforced concrete. The difficulty of the work was greatly increased by the unusual height of the permanent way—about 133 ft. above high-water level—and by the rapidity of the current of water. The great depth of the valley necessitated a bridge of unusual length and the total length when finished is 630 ft.

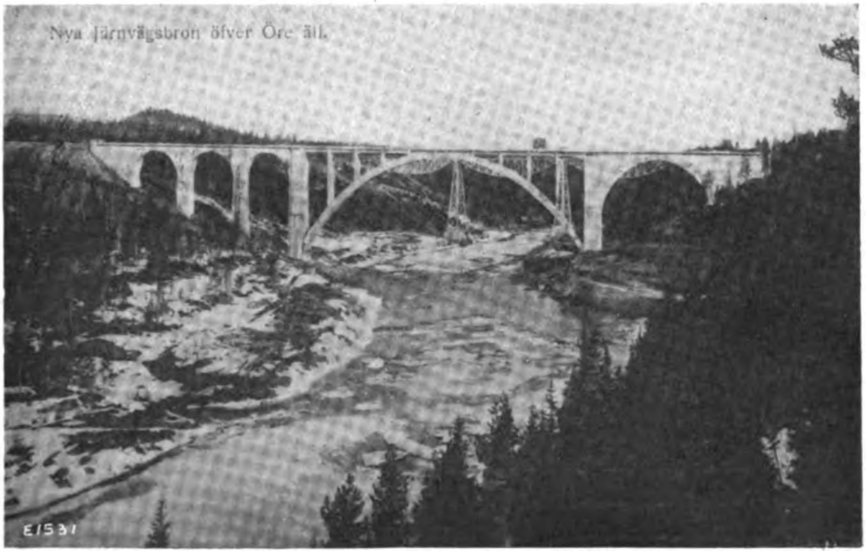

FIG. 1. GENERAL VIEW OF BRIDGE.

The bridge consists of the large centre arch, which is its chief feature, and four smaller arches, of which three are on the west and one on the east bank of the river.

The central arch was made in three pieces, united with hinged joints.

Each section is 8 ft. at the centre and decreases to 5 ft. thick at the hinges. These consisted of five sets of cast steel bearings with plates 2 ft. 6 in. wide by 4 ft. 6 in. long against the concrete, the five bearings being connected with a tie-rod 23 ft. long and 3¼ in. diameter. The wooden centering for the arch was built on four large piers of wood, the struts being tied from one pier to another at a height of about 45 ft. On the platform thus made, the rest of the centering of the arch was built in the customary manner.

At the crown, the central arch is 17 ft. wide and it gradually increases to 24 ft. 6 in. at the abutments. The thickness of the concrete at the crown of this arch is 4 ft. 6 in.

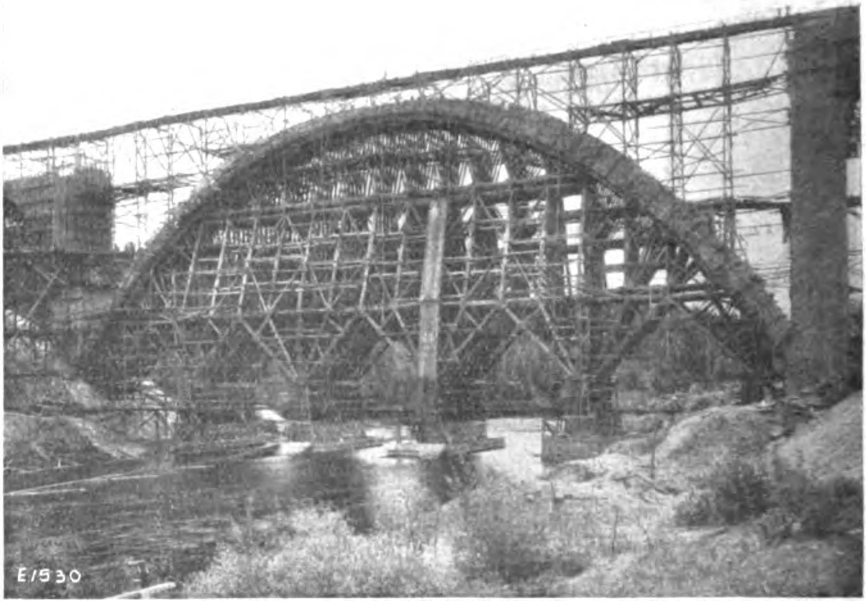

Fig. 2. Skeleton and Centering Work.

The reinforcement consisted of 64 one-inch bars in the centre of the arch and 40 bars at the ends, in addition to the stirrups of ⅝-in. round iron placed 2 ft. apart and rather farther apart at the hinges. The arrangement of this reinforcement calls for no special comment.

The concrete consisted of one part of cement, three parts of sand and four parts of broken stone in the main arch, but above a concrete composed of the same materials in the proportions 1 : 6 : 8 was used and for the abutments an average of 1 : 5 : 7 was employed. The ratio of steel to concrete is 0·1 per cent.

The main abutments are 16 ft. deep and 26 ft. wide and 134 ft. high; they are reinforced with old rails. To ensure stability, each abutment rests on 332 concrete piles each 1 ft. square and capable of carrying a dead-weight of 34 tons. The abutment on the east bank rests on similar piles, but those on the west bank are built directly on the ground as the foundation on that bank was deemed sufficiently good.

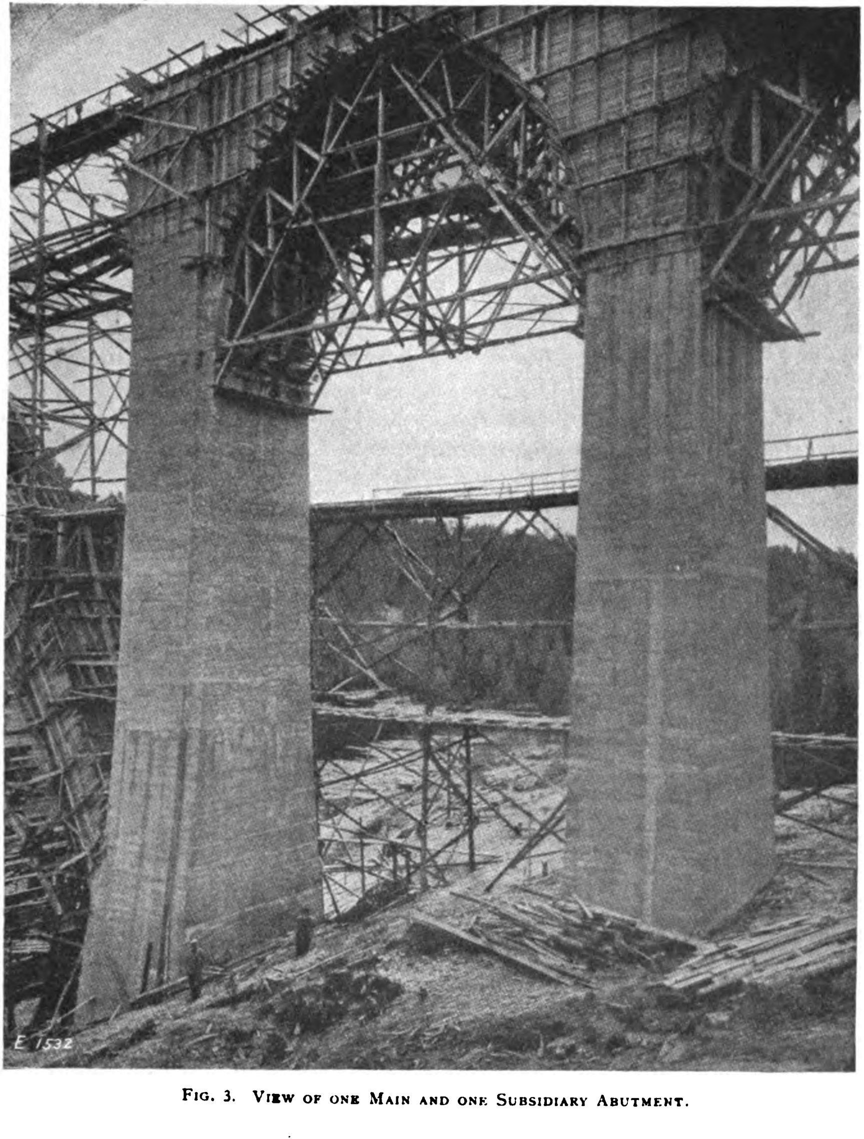

FIG. 3. VIEW OF ONE MAIN AND ONE SUBSIDIARY ABUTMENT.

The subsidiary arches call for little comment, as they do not present any special features.

The permanent way is supported by plate girders of 30 ft. span, securely anchored to the concrete and provided with hinges like the latter.

After the bridge was completed it was left for a year in order that the cement might set properly, as it was thought necessary to avoid all risks with so large a span. Before being used, it was tested by running two heavy locomotives and five extra heavily loaded trucks. The deflection during the trials was 0·4 in. and the permanent set 0·06 in., which may be regarded as wholly satisfactory.

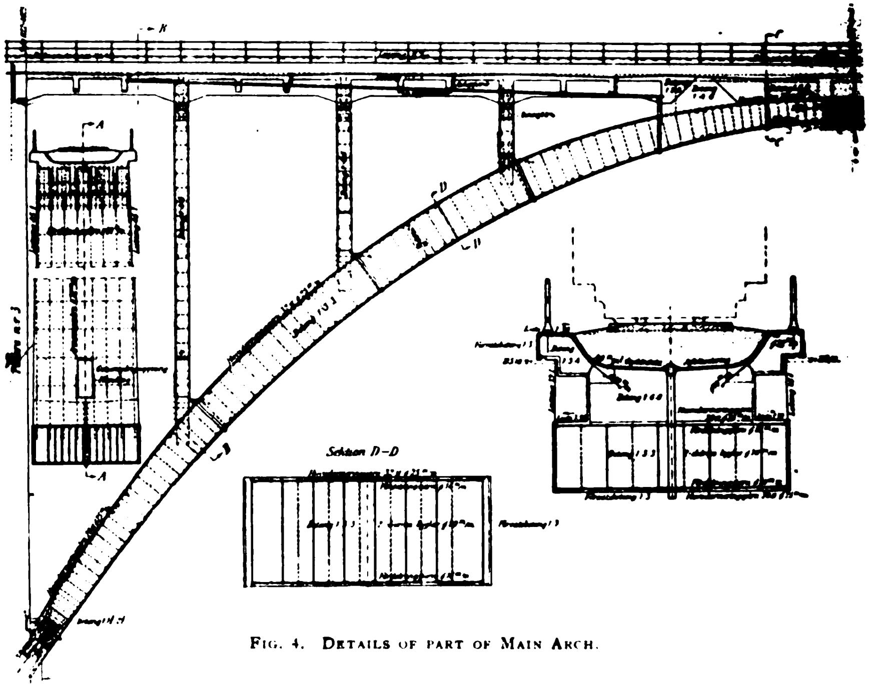

FIG. 4. DETAILS OF PART OF MAIN ARCH.

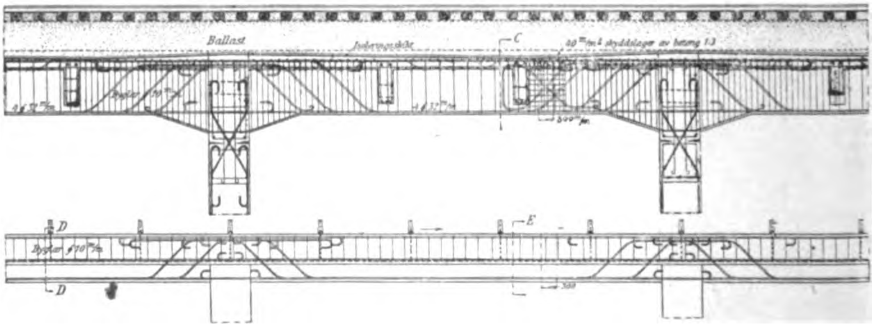

FIG. 5. REINFORCEMENT OF PERMANENT WAY.

The cost of the bridge was £78,000, and in addition to this the cost of railway diversion and auxiliary work must be added, bringing the total to close upon £110,000. The main arch cost £29,250, of which £8,000 represents the actual concrete work, £1,800 the hinges and the remainder the cost of the wooden centering under the arch.

# TRIMSTONE AND BUILDING ORNAMENTS.

By ADOLF SCHILLING.

*The above was the title of a paper read this year at the National Conference on Concrete Housing, U.S.A. Below we reproduce the paper, practically in full, from the "American Architect."—ED.*

FIFTEEN years ago, when I started to make concrete attractive and pleasing to the eye, I accepted a definitely settled concrete's claim for strength and endurance, demonstrated by the engineers in their work of that time and by the examples of ancient concrete work still in existence, some of it dating back 2,000 years.

My researches and experiments have been devoted entirely to giving concrete the attractive and artistic qualities which would make it interesting to the architect and decorator as a medium for embellishment and actual construction in their work.

In the making of concrete, after once thoroughly understanding the qualities of cement as a binder or matrix, one can learn to adopt many mineral and metal resources as readily as we employ the better known sand, gravel, and crushed stone for aggregates.

*Building Trim.*—After proving that cast stone could be made successfully, it required considerable missionary work to convince the architect of its merits and advantages for use in building construction and enrichment of design, so far claimed by terra cotta, natural stones, faience, etc.

The field has been opened and it now rests with the individual and joint effort of everybody producing concrete units for building purposes to convince the architect, engineer and contractor that standard concrete products are what they want and can get, no matter if it is for the foundation or for the richly ornamented entrance of the work in hand. It must be our purpose to establish co-operation that offers dependable concrete products to meet the requirements of the building trade in quality and quantity.

To cover the methods of manufacture in detail would exceed the limit of this report. Plaster, glue, wood, sand, cement and steel moulds have been used successfully.

A kind of mould extensively used is made of channel irons, in sizes from 2 in. into 18 in. wide, and in lengths from 4 ft. to 8 ft. If set on level tables or benches, the main part of a mould is provided that offers great flexibility in its use; the channel irons are held together by different length rods at the ends; wood or plaster inserts, plain or moulded, determine the width, length and design of the unit to be cast. The work is poured with finished face down and can be solid or hollow, surfaced with special material on any one side or all four sides, if the volume of the stone makes it more economical to use a core of less valuable aggregates.

Some excellent work has been done modelling directly with cement mortar by artists who have attained their efficiency in this method abroad; the most important work of this kind, to my knowledge, is a group of the Crucifixion of heroic size, at Lynn, Mass.

The artist builds up his design with permanent skeleton framework, similar to modelling in clay. Around this skeleton he forms a rough outline of the design in wire cloth or expanded metal, and on this is placed a scratch coat of cement mortar on which, when set, he begins to model the final outline of his design. The artist is enabled, by using mixtures of quick and slow setting cement mortars to regulate his medium. In this way he can give the work the same freedom and spirit as if he modelled in clay, producing any texture desired; colour effects can be obtained at random by using coloured cement of various shades; for instance, a garland of flowers can be modelled in their natural colours. There is no difficulty in producing in cement the well-known Della Robbia effects, the same as is done in faience and coloured marble. This method is particularly of interest and value where only one piece of a large ornamental design is to be used, thus avoiding the expense of moulds and setting the cast in place.

For treating surfaces electric rubbing wheels are used to produce a smooth finish. acid for grain texture finish, and any of the tools used in the natural stone trade for cut finishes, according to the effect desired in the cast stone; any one or all treatments may be used on one piece. Transportable rubbing and tooling machines are employed to surface the extra heavy casting, and stationary machines for the smaller units. A cutting plant for natural stone is an ideal foundation to start an up-to-date cut cast stone business, even to the use of its rubbing beds and gang saws.

Concrete of proper age can be treated just like any natural stone, using the same tools and machinery to dress its surfaces, or to saw cast blocks of large size into slabs and strips. It is the author's strong conviction that the success of concrete stone for building purposes rests in a close affiliation of the stone caster and the stone cutter. Only in this way will it be possible to give concrete proper texture and the necessary qualities of dimension stone, so essential to the architect and builder for durable and attractive construction.

The addition to every concrete products plant of skilled stone cutters would be a source of profit and also result in better work. The stone cutter is trained to have dimension stone true to size and shape. The average worker in cement or concrete does not appreciate this essential point, but it is all-important with the architect and general contractor. The services of a stone setter will enable the concrete products plant to set its own work, which is very desirable for the best results. It was found that the brick or natural stone mason did not give composition stone the required care when setting same, for reasons of trade jealousy, but once this fraternity understood that concrete stone gave extensive employment to stone cutters and setters, their antagonism vanished as they realised their own benefit in the broader use of cast stone. Whenever the opportunity presents itself, a closer affiliation of the composite and natural stone trades is recommended. The enormous increase in all building operations of whatever class and the constant effort for betterment in the moderate-priced home. give abundant field for both trades in a more permanent class of work and at more satisfactory profits.

It has taken many years to bring the craft of dressing natural stone to its present efficiency. The progressive concrete products man should study these methods and benefit by the experience of the trade whose product he must equal or better to meet approval by the architect.

To the manufacturer or worker of concrete products the author further recommends the adoption of such methods as are employed successfully in other lines of manufacture in treating the surfaces of their product. In many cases instead of applying paint with brush, the article is immersed in the paint. This method can be adapted to acid washing of the concrete products, to remove the surface film and expose the aggregates. Tanks of sufficient size are not a hard matter to construct in the concrete shop, and the immersion of concrete products in acid solution will not only prove a great saving of acid and labour, but produce a class of work that cannot be obtained with the scrubbing brush. The writer uses two rectangular tanks 4 by 4 by 16 built of cement slabs, grooved and bolted together, and six circular wood tanks 7 ft. diameter and from 2 to 4 ft. deep. Concrete should be from two to three weeks old before treating in acid bath ; duration of bath depends on age of the stone, and if rough or fine texture is desired, the time being from one to ten hours. A solution from 1 to 20 up to 1 to 10 is recommended, and after the article is put in the tank the solution does the rest. This style treatment preserves the edges and details of the design and makes the surface uniform. Any of the hard spots not sufficiently affected by the acid bath can be treated separately after the article has been flushed with clean water. Care must be taken that the aggregates of the surface are nearly uniform in hardness, or the acid will destroy the soft portion before the harder particles have been cleaned of the cement coating. Some very fine work has been spoiled where, to obtain a certain effect, black marble (a limestone) and crushed granite were mixed. The acid bath left only the holes where the black marble had been, while the granite showed a very fine texture and natural colour. Judicious handling of this effect can produce desired results in texture, like Travertine stone, etc.

*Colour Effects.*—To produce colour effects gray or white Portland cements can be used, separate or mixed in certain proportions, adding to this suitable pigments, but in such cases the natural coloured aggregates, sand, silica, pebble grits, marble and granite, will give excellent and more uniform results. It requires great skill and care to properly mix cement and colour pigments without reducing the strength of the cement and still obtain good colour effects.

The importance of mixing the pigment thoroughly with the cement, before adding the aggregates, should be understood before attempting to make concrete in colours successfully on a large scale.

As a very simple method to test the proper amalgamation of the pigment with the cement, take a handful of the dry mixture and press it under a sheet of stiff paper ; this will produce an even surface of the material, and when this surface does not show absolute uniformity in colour the mixing is incomplete. If small specks of colour show under this test, these same specks of unassimilated pigment will appear in the finished concrete. So far a very important factor that can be utilised for colouring concrete or cement has been given little or no attention ; while very simple in its primary action, the successful application requires thorough understanding of the principle and medium employed.

This refers to the absorptive qualities of concrete during its stage of curing and seasoning, which offer opportunities for colouring concrete products by capillary action. By this method the colour is deposited into the pores of the surface, amalgamating with the concrete into a permanent unit. The possibilities of this treatment are unlimited if based on knowledge of colouring values and good judgment not to impair the strength requirements of concrete. Colouring solution can be made to penetrate the surface of concrete 6 in. or more, if the object is immersed while in a very green state, but it is rarely necessary to penetrate more than 1/32 to ⅛ of an inch ; this thoroughly fills all pores, gives the desired colour effects and is less expensive. Every atom of colouring absorbed by the concrete reduces the strength of the solution; and as some of the colouring matter used is quite expensive, good judgment to allow only the necessary absorption of colouring matter is advisable from an economic standpoint. The sulphates of copper and iron are the most suitable to make solutions to colour concrete by the capillary method.

Concrete can be so treated after it is a week old. When used in construction and carrying loads it should not be subjected to the colouring bath until the concrete has attained its required strength, as the filling of the pores in the concrete retards the action of hardening. Colouring by absorption is effective on concrete after it comes out of the mould or after being treated with tools. Surfaces that have been coloured by absorbing mineral or metallic colours become more weatherproof and the action of the weather on the metallic colours increasing the beauty of colouring by the usual oxidation noticed on bronze and copper. Concrete treated by this method becomes so hard and dense that it will take a polish. I have treated its surfaces in the same manner as marble, granite and metal under polishing or buffing machines.

Wet cast concrete products, such as flower pots, vases and boxes, will hold water after the second day of casting and become so hard that when struck with a hammer they ring like a metal bell; waterproofing compound helps, but is not essential to obtain this result. The thorough mixing of the proper amount of cement and water with graded aggregates is all-important. Extensive tests made during the past three years with commercial waterproof paints produced excellent results. Common concrete can be made very attractive by one or two coats, and applied in stipple fashion it will not impair the grain or texture, avoiding the undesirable appearance of brush-painted stone. This method is especially to be recommended for dry or semi-dry tamped concrete work; the porous surface readily absorbs the waterproof liquid and thereby allows the pigment particles to fill the pores.

By using spraying machine the colour effect is obtained most economically. It gives a uniform colour or can be varied to give the richness and depth of shading that results from this treatment in experienced hands. It can be applied where immersion is not practicable. Two and three colour effects have been obtained by painting certain parts of an object before subjecting same to the colouring bath. The parts so coloured would not be affected by the colour in the bath, the absorptive quality having been neutralised.

The artistic possibilities of such treatment are only limited by the colour sense and taste of the craftsman. Using certain non-absorptive aggregates their natural colour can be retained, while the absorptive parts, especially the cement mortar, will assume the desired colour. Precaution must be taken in the use of acid washing before immersion in the colour bath as the chemical action of the acids is liable to counteract the colour values of the bath. Acid should not be employed after concrete is treated with colours. Long practice and tests will give the full benefit of this process.

*Surface Finish.*—In the matter of surface finishes, considerable headway has been made. Many of the methods are so simple and inexpensive that concrete need not remain unattractive to the architect.

Most of the writer's trimstone and ornamental work is wet cast, it is required to stay in the mould from 24 to 48 hours, and a 4 per cent. solution of calcium chloride is used for the mixing water; during cold weather the shops are steam heated and kept at a temperature of 70 degrees.

No curing rooms are used, but for quick hardening high-pressure steam cylinders 6 ft. in diameter and 70 ft. long are employed. The writer's firm have commercially verified the tests made some years ago by the U.S. Bureau of Standards and reported in Technologic Paper No. 5.

While these tests did not exceed 80 pounds pressure, concrete has been hardened with 150 pounds steam pressure, obtaining results so that concrete 2 days old could be tooled under rapidly revolving carborundum wheels, cutting flint aggregates without pulling out or fraying the edges. The mixtures used were from 1 to 10 to 1 to 5. Compression tests showed over 4,000 pounds in two days and absorption less than 5 per cent. The higher the steam pressure the less time it requires to harden. With 150 pounds the time was reduced to 4 hours, besides the two to three hours it requires to bring the pressure up to 150 pounds. Concrete so hardened has been subjected to weathering for several years, proving equal to naturally hardened concrete

No Portland cement concrete product should be subject to high-pressure steam curing until it has its initial set. The steam hardening should start preferably the day following the casting.

Tamped concrete should be kept moist until it goes into the cylinder. As the expense of equipment and operating is considerably higher than curing rooms, only units that lend themselves to completely filling the cylinder space can be hardened economically, like brick, tile or blocks.

In conclusion the author maintains that with honest concrete the architect, engineer and builder can be interested in its general use.

Crushed marble and granite with Portland cement as a binder produces a reconstructed stone of natural components which can be dressed and finished like natural stone without being an *imitation* stone or a misuse of *concrete*. It gives us a staple building material, combining the beauty in colour and texture of the natural stones with the strength and economy of concrete.

## MEMORANDA.

**Concrete Roads.**—The Portland Cement Association of Canada has issued a pamphlet entitled *Curing Concrete Pavements Laid in Warm Weather*, in which an exhaustive study of concrete road work is made. After giving the results of tests showing the value of keeping the concrete moist for a period of at least 28 days after it is laid, various methods in use in Canada for attaining this desirable object are described. In addition to the well-known methods of covering the finished surface with earth and wet straw, and sprinkling at regular intervals, a method of completely flooding the surface is detailed. In this method, which, of course, can only be used for country roads, dykes of sufficient height to maintain a depth of two inches of water over the crown of the road are built of earth along the sides of the road, and transversely at intervals. The ponds thus formed are filled with water three times a day for approximately one month.

With regard to shrinkage cracks, which are such a frequent cause of annoyance, the report says: "The only sure way to prevent shrinkage is (1) to use the least amount of mixing water that will produce a workable concrete, and (2) delay the finishing operations until the concrete has begun to stiffen slightly. Then continue working the surface, either by floating, rolling or with the tamping machine, until the entire thickness of the slab is of uniform density, the surplus moisture squeezed out, and the initial hardening well advanced. Sometimes prompt covering with wet canvas is sufficient to prevent cracking, although this is not a sure cure. It is of advantage to have the canvas cover supported on frames of sufficient height so that the finishers can work underneath when shrinkage cracks are troublesome."

**Concrete Roads at Tilbury.**—The Tilbury Urban District Council has reconsidered the question of the roads to be constructed in connection with the large housing scheme which it is carrying out. The original scheme provided for 2½ miles of concrete roads and 4 miles of tar-macadam roads, but we learn that, after the examination of the contract quantities by an independent surveyor, it has been found advantageous to carry out the whole of the work in reinforced concrete, in spite of the fact that it will be necessary to duplicate the gas and water mains.

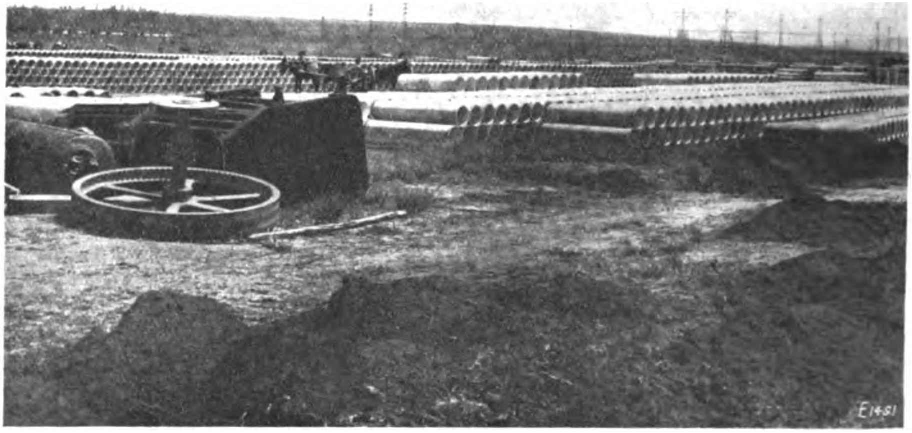

FIG. 1. GENERAL VIEW OF THE COMPANY'S YARD AT THEIR SOUTH AFRICAN WORKS.

# THE "HUME" PIPE.

A NOVEL and interesting method of making concrete pipes was invented and patented by Messrs. Hume Bros., of Adelaide, Australia, about ten years ago. Since that time works have been opened in South Africa and India, and at the present time plant is being laid down for the manufacture in this country. The process constitutes an entire innovation, and may possibly bring about a complete revolution in pipe-making.

The employment of concrete for making pipes is, of course, not new, as such pipes have been in use for many years, but the method usually adopted involves the use of an inner and an outer mould, between which the reinforcement has to be placed with the utmost care, and the concrete consolidated by tamping or jigging. For this reason the length of pipe which can be moulded in one operation can only be short—say from 3 to 4 ft. By the new method, however, pipes up to 12 ft. are made, and as far as the process itself is concerned there is no reason why they should not be made in even greater lengths than this.

Then again, many of the old methods resulted in a more or less porous concrete, but for the method under review absolute impermeability is claimed.

The process is a rapid one, and, like many great inventions, is remarkable for its simplicity. In brief it is as follows :—A metal mould, having an internal diameter equal to the external diameter of the pipe, is fitted at the ends with an outer flange and an inner ring, the latter in each case being equal in depth to the required thickness of the wall of the pipe. Inside this cylinder or mould is placed a spiral cage of wire reinforcement which has been woven into shape on a separate machine and which varies in weight and strength according to the pressure the pipe is designed to carry when finished ; the whole is then laid on friction rollers and rotated. While the machine is running a sufficient quantity of wet concrete material to give the required thickness of the pipe is placed in the cylinder, which is further rotated at a calculated speed. At the end of a short period, usually four or five minutes, the excess water has been expelled from the concrete, the machine is stopped, and the water allowed to run out. The machine is then restarted, and the mould with the pipe is re-spun for another few minutes, which causes the final drying of the interior surface.

*The Effects of Centrifugal Force.*—The main result of the rotation is that, by centrifugal force, the concrete material is distributed with perfect evenness throughout the whole length of the cylinder, and is pressed outwards until it rests, a compact mass, against the mould, completely embedding the reinforcement.

A secondary effect which follows upon the former is that as the solid particles are pressed outwards against the mould the water is forced inwards, and by the time the pipe has finished its first spin nearly all the water that was put originally into the concrete has been brought to the inner surface, only sufficient being left behind for the necessary crystallisation in setting. The result is a concrete wall of intense density; in fact, when the first spin is over the material in the cylinder is so hard that it is impossible to make an impression with the thumb on the inner surface of the pipe.

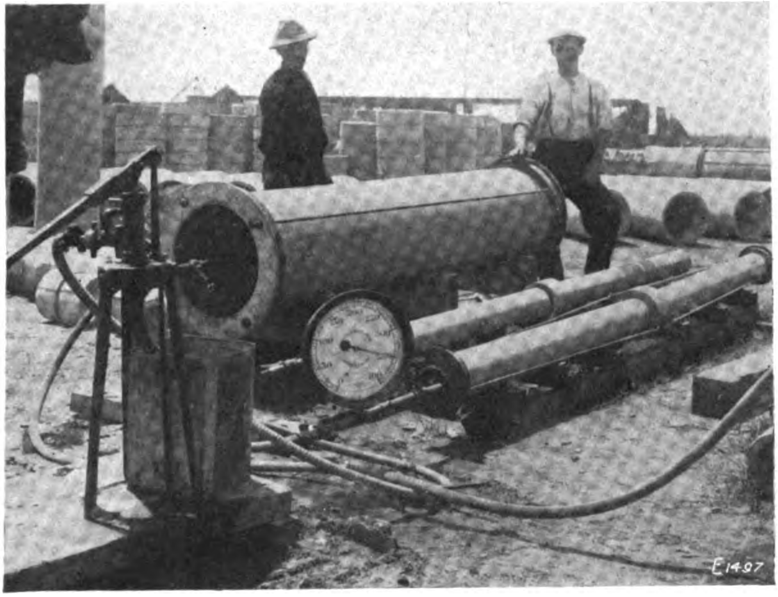

FIG. 2. PRESSURE PIPE UNDER TEST.

Again, since the heavier are the particles the greater is the force with which they are pressed outwards, any light material which might be present in the aggregate must, like the liquid, necessarily come to the surface and be evacuated with the water.

*Reinforcement.*—Two classes of pipes are made—pressure pipes and non-pressure pipes. The usual machine for weaving the reinforcement for pressure pipes consists of a shaft carrying a collapsible drum made of mild steel in four to eight longitudinal sections.

The drum is expanded by means of cones which are operated by a toggle on the shaft. These cones, in addition to expanding the drum, thrust out a series of pins which project at right angles to the curved surface at both ends. Power is transmitted direct to the shaft, and this, acting through a series of gear wheels and pinions, operates a traveller which winds the wire spirally the length of the pipe, the end of the wire having been anchored to one of the aforementioned pins. Longitudinal wires, which are also anchored to the pins, are then put on by hand over the top of the spiral, and this having been done, the operation is repeated till the necessary strength is given.

This machine is designed to give the wire an even pitch, but the pitch is variable according to the amount of wire required to be put into the pipe to resist the pressure which it will ultimately be called upon to withstand.

Owing to the high tensile strength of steel wire as against cast iron or steel tubing, the weight of metal in " Hume " pipes is comparatively small. The reinforcement is completely protected from electrolysis or from any action of atmosphere, water, or even from acid in the pipe. It is not yet known how long the life of these pipes is, but for all practical purposes it is claimed that they may be regarded as everlasting.

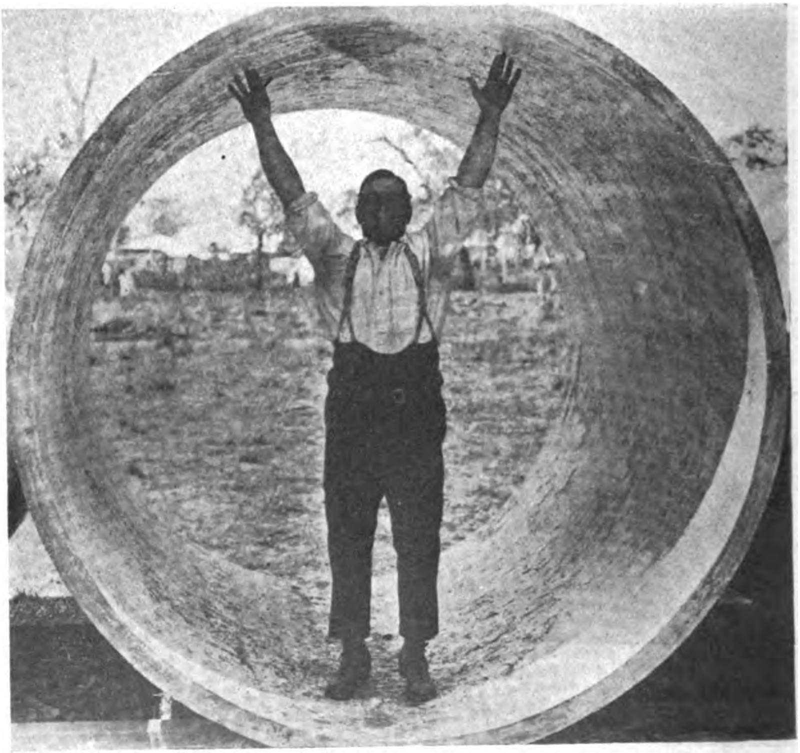

Fig. 3. A 7-ft. Pipe.

Pressure pipes have been supplied up to 350 lb. per inch, as shown in the test illustrated in *Fig*. 2, at which pressure they are perfectly dry. So dense is the concrete that it will stand pressure up to 400 lb. per sq. in., provided the reinforcement is sufficient to retain it in position, the theory being that the reinforcement takes the stress while the concrete renders the pipe waterproof.

We are told that a pipe has been filled with a mixture of petrol and paraffin and placed under a pressure of 200 lb. per sq. in., and at the end of three months there was not the slightest sign of percolation.

Of these pressure pipes 279 miles have been laid in Australia and 100 miles in South Africa, the working pressures varying from 75 to 250 lb. per sq. in.

*Non-Pressure Pipes.*—These are employed for sewage, drainage, and in any position where they are not subject to internal pressure. They are either lightly reinforced or not reinforced at all, according to their size and the conditions under which they will be used. They have been made for culverts 8 ft. in diameter and for all other purposes down to 4-in. telephone conduits. A 7-ft. pipe is shown in *Fig.* 3.

This type of pipe has been extensively used in Johannesburg for ventilation purposes in the mines, and there is a steadily growing demand for the Hume pipe for this purpose. They were made 15 in. in diameter, with a wall $\frac{3}{16}$ in. thick, ordinary chicken wire netting being used as reinforcement. It is said that one man can with ease lift and carry off one of these 6 ft. by 15 in. pipes. Before use, and after they had been made a fortnight, they were tested by standing six men on each.

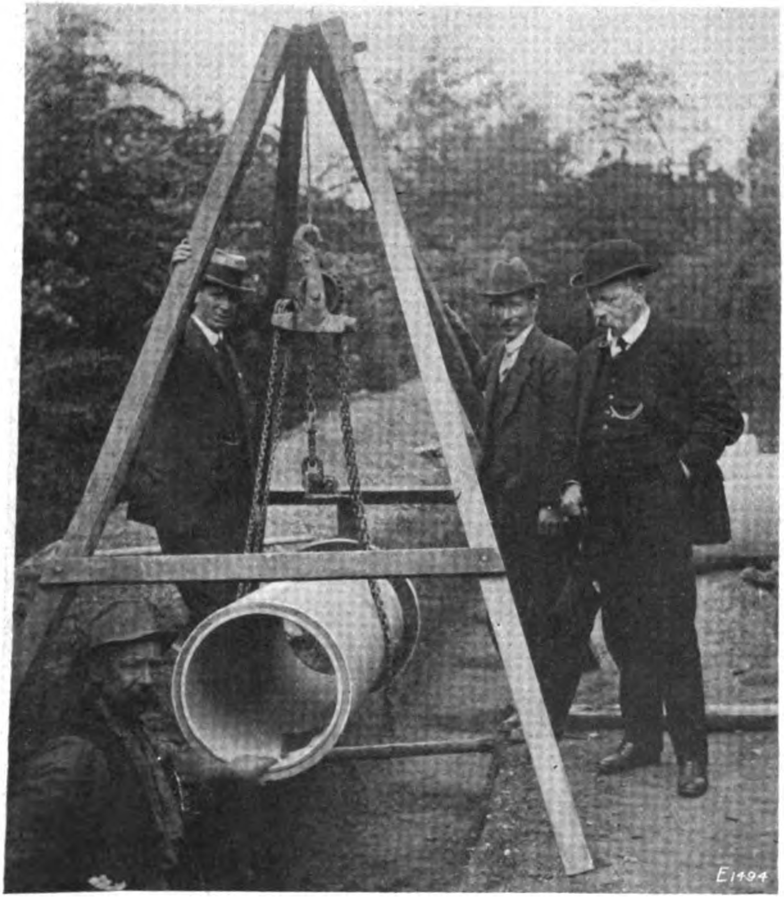

FIG. 4. SHOWING THE V-GROOVE OF PIPE.

Pipes with walls up to 1 ft. thick have been made in Australian naval bases to be used instead of piles.

*Jointing.*—All pipes constructed to carry internal pressures are moulded with a V-groove sunk in the ends of the wall, which may be clearly seen in *Fig.* 4, and which, when the pipes are butted forms a cavity of diamond-shaped section. This cavity is filled with a plastic material, and the shape of the cavity being what it is, any internal pressure which may tend to drive the water outwards through the joint wedges the plastic material more firmly in. The joint is finally covered by a reinforced concrete collar made in the same manner as the pipe, only of greater diameter, and, of course, of suitable width. The collar, which is practically a movable socket, and is usually 6 in. wide, does not fit closely on to the pipe, but it is separated from it by a space varying from ⅜ in. to ¾ in., according to the size of the pipe. This space may be caulked with a rather dry cement mixture or with lead as desired. A pipe line is shown in *Fig.* 5 in which the collars may be clearly distinguished.

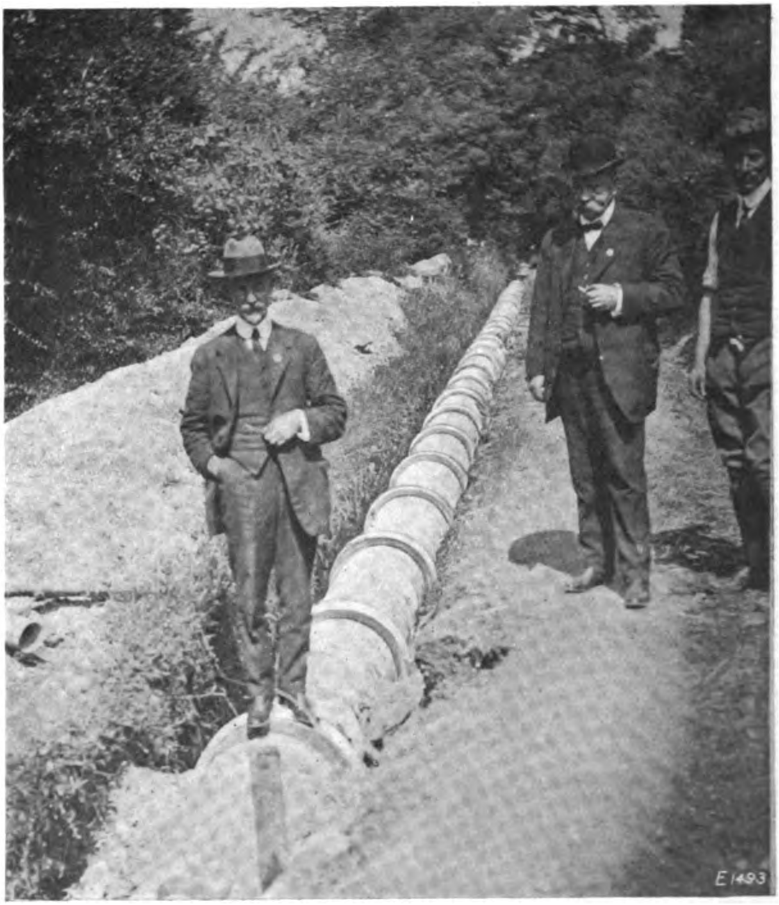

Fig. 5. A Pipe Line showing the Collars.

The whole arrangement constitutes a most effective joint, capable of "taking up" any expansion or contraction that may occur in the pipe. The collar being roughened internally during manufacture, the packing adheres to it rather than to the pipe, which is smooth, therefore the action of any expansion or contraction in the line takes place between the inside packing of the collar and the surface of the pipe, so that when the pipes pull apart the groove, or recess, at the end tends to gape.

The shape of this recess is so designed that the plastic material, whilst adhering to all surfaces with which it is in contact, is drawn up, presenting a crucible-shaped face to the water-pressure in the pipe, which face increases or decreases on a curve varying with the extent of the expansion or contraction, thus giving a water-tight joint under all conditions.

It is a noteworthy fact that in all the pressure tests which have been carried out on the " Hume " pipe no example has ever given way at the joint.

*Crushing Strength.*—Culvert pipes up to 36-in. diameter, made with a 4 : 1 mixture and having walls 1¾ in. to 2 in. in thickness, carry a load of 4,000 lb. per lineal yd. external pressure, tests being made to apply this pressure by means of a dead load resting on a 2-in. bar placed longitudinally on the pipe.

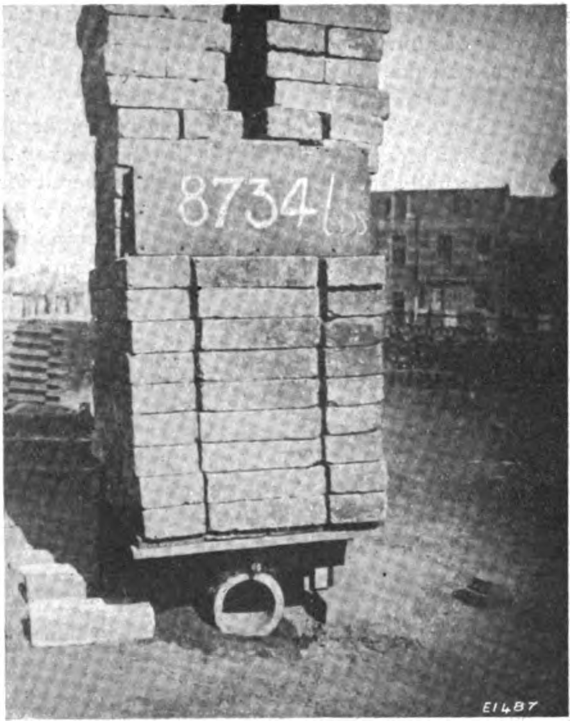

FIG. 6. A 3-FT. LENGTH OF 10-IN. SEWER PIPE UNDER TEST.

On April 15th, 1919, a test on a 3-ft. length of lightly reinforced 10-in. concrete sewer pipe was made by Mr. Burt Andrews, the town engineer of Johannesburg, in connection with a contract for the supply of pipes for the municipality. The pipe had a wall 1⅛ in. thick. The test consisted in the application of an external load bearing on a round 2-in. bar along the top of the pipe, which itself rested on a bed of sand without any side supports. The pipe was subjected to a load of 4,000 lb., and at this point showed only the faintest hair cracks. It was decided to load the specimen to collapse, and at 8,734 lb., the limit of loading, the pipe still held up. At this point the vertical diameter had been reduced from 10 in. to 8⅞ in. and the horizontal diameter increased from 10 in. to 10⅝ in. On removing the load, the vertical diameter recovered to 9 in. and the horizontal to 10½ in. Although this pipe had not returned to its original shape it was quite serviceable, and still capable of standing double the required stress. A photograph taken during this test is shown in *Fig.* 6.

It has been a common practice to protect concrete pipes for drainage under roads with a concrete shield. It is claimed that the "Hume" pipe needs no such protection. A severe test was applied in work undertaken some time ago by Messrs. Hume Bros., of Adelaide. In order to make up lost time certain 42-in. diameter drain pipes were laid and jointed six days after manufacture. The pipe track was laid 1 ft. below ground level. One month from date of manufacture they were tested by passing a heavy steam roller backwards and forwards, both directly and diagonally, over the pipe line without any ill effect whatever.

*Flexibility.*—Although it is well known to engineers, but disputed by several writers to the press, that there is a certain amount of flexibility in reinforced concrete, as proved in the warping of flumes and the oscillation of buildings, the study of this feature is not complete, and one experience, therefore, of the "Hume" pipe may be of interest.

A 36-in. rising pumping main (two miles of which were under a head of 160 ft., was laid under contract by Messrs. Hume Bros. on the Murray River, Australia. The pipe line, although actually in use, had been left uncovered for inspection, and therefore exposed to variations of temperature. In the heavy floods of 1915 the Murray overflowed its banks, and, floating up the empty pipe line, bent it down stream. The subsiding flood left the pipe line 6 ft. out of truth, and, due to wash-aways, some sections were suspended in air. Several days later pumping was resumed as a test, no repairs or adjustment of any kind having been attempted in the meantime. One collar was found to be cracked and was strapped with an iron band for safety, but as there was no leak and no other evidence of strain or drainage, the pipe was allowed to remain in use in that condition.

*Other Applications of the "Hume" Pipe Process.*—The output of this process is not confined to pipes. Other products are building blocks, roofing and other tiles, columns, chimneys, gargoyles, guttering and down spouts, circular tanks, railway sleepers, pit-props, hollow fencing posts, telegraph poles and well-linings, while silos and round huts up to 14 ft. in diameter are in contemplation.

To sum up, the claims made for the "Hume" pipe are:—

1. That it is not subject to electrolysis, corrosion or incrustation.
2. When constructed for a given pressure it is impervious at that pressure.
3. It is perfectly smooth both internally as well as externally, and thus the coefficient of friction is reduced to a minimum.
4. That this pipe is made up to 12 ft. lengths, and thus the extra expense of jointing is considerably cut down.
5. It is lighter in weight than cast iron or ordinary concrete pipes, and therefore requires less handling and consequently is cheaper to move about.
6. It will carry heavy hydraulic pressures and external loads.
7. It can, so far as experiments show, carry oil, both crude and refined, without ill effects in either case.
8. It is cheaper than pipes of cast iron or steel.

Such are the claims made for the "Hume" pipe, but whether in the course of time all these claims will be substantiated or not remains to be seen. At any rate, sufficient has been said and enough has been done to show that this process is worthy the attention of all engineers.

# THE FOREIGN PRESS.

*The following are abstracts taken from the foreign Press relating to concrete construction.—ED.*

**The Poyet Floor.**—As the use of timber shuttering is now so costly, increasing attention is being paid to hollow clay slabs. Among others, a reinforced slab of this character, invented by C. Poyet, is worth consideration. It consists of a slab 12 in. by 6¾ in. by 1¼ in., with three longtitudinal slots and a semi-circular channel along each side. Reinforcing bars are laid so that they fill the spaces between the channels when two rows of slabs are laid side by side, any intervening space being filled with concrete or mortar (see *Fig.* 1, which represents a cross-section of a central slab and of portions of two slabs—one on each side of it). The wooden supports required are reduced to those needed to carry the reinforcing bars (*Fig.* 2).—Proprietor : A. Minangoy, 26, Place du Marché, St. Honoré, Paris. *Revue des Matériaux de Constructions.*

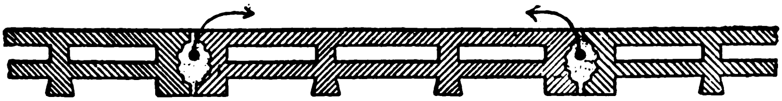

Fig. 1.

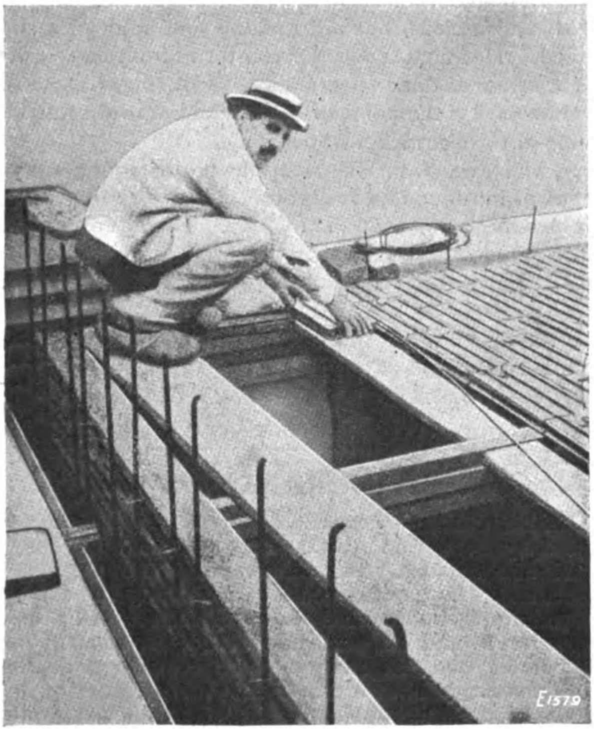

Fig. 2.

**Concrete and Electrical Accidents.**—The effect of electric currents on concrete has been made the subject of several enquiries, but the results show such variations in the electrical conductivity of concretes of different origins as to leave the matter open for further investigation. It was found by Lindeck, as far back as 1896, that the nature of the concrete had a notable effect on its resistance, and the latter being roughly proportional to the amount of coarse aggregate present.

O. Berndt and his associates, in 1908-1911, showed that the concrete blocks act as a single electrical element, that the polarisation current between electrodes in the concrete flows in different directions according to the arrangement of the aggregate, that the electrical resistance of the concrete increases with the temperature, the dryness and the hardening of the concrete, and diminishes with the wetness of the material. These investigators also showed that the electrical conductivity was also affected by the proportions of cement and aggregate, and by the consistency of the freshly-made mixture, and by the dampness or dryness of the finished and hardened blocks. In short, one of the most important deductions from Berndt's work is that only dry concrete is an effective electrical insulator.

Berndt, Wirtz and Preuss have also investigated the electrolytic phenomena in concrete, especially those alleged to be the cause of superficial cracks, and found that the effect of lightning-like discharges was only serious when the concrete was perfectly dry. Ruppel, on the contrary, found that partial fusion and serious disintegration occurred even with moist concrete if a sufficiently intense current was used.

More recently, S. Jellinek (*Beton u. Eisen*, 1920, p. 28), has investigated two cases: (*a*) in which a healthy young electrician standing on a block of concrete touched a circuit through which a high tension current of 5,000 volts was passing, received a shock which rendered him unconscious, but did not kill him, and (*b*) a similar occurrence in which the man died. He found in case (*a*), a footprint from the sole of the electrician's shoe consisting of a series of dark spots indicative of singed material. These spots could readily be removed by the point of a knife and agreed completely with singed leather from the sole of the electrician's other shoe.

In the case (*b*), which was fatal, the footprint presented a geometrical appearance but showed no signs of burning, and it was too thin to be removed. The shoe itself did not appear to have been damaged in any way. Patches of dirt on the sole of the deceased man's shoe were found to be conductive, whilst the shoe itself had a high insulating value, whilst the absence of any such conducting material in case (*a*) is significant.

In both cases the dry concrete proved to be a fair conductor, and to this must probably be attributed the cause of the accident. When the concrete was wetted its potential difference rose from 1,500 to 3,900 volts, so that wet concrete is much safer than the dry material.

## MEMORANDUM.

**Testing Sand for Impurities.**—A method of determining the existence of impurities in sand is suggested by Prof. Duff Abrams and Dr. Oscar Harder, as the result of investigations in this direction which they have carried out at the Research Laboratory of the Lewis Institute. This method consists of shaking the sand thoroughly in a dilute solution of sodium hydroxide and observing the colour of the mixture after it has stood for a few hours, and the sand has settled. A clear or pale yellow liquid above the sand denotes that the sand may be considered as free from organic impurities, while if the liquid is of a darker hue the presence of organic impurities is indicated, and the sand should not be considered fit for use in high-class concrete and might have to be rejected altogether. Sand which may appear dirty, providing it is free from organic impurities and is of durable quality and properly graded, will give quite satisfactory results when used for making concrete, and this test, which is said to have been already largely adopted in America, appears to be a simple method of ascertaining whether such impurities are present or not.

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

*In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.--ED.*

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*Question.*—V. W. *writes* :—(1) *In ordinary general practice, when designing beam and slab floors, where both beams and slabs are continuous over a number of spans, are the bending moments determined by the theorem of three moments, or graphically, or is a safe assumption taken, and is continuity considered not to exist over more than three spans ?* (2) *Are there any text-books which explain in a simple manner the theorem of three moments and give examples of the application ?*

*Answer.*—Graphical treatment is very seldom employed in general practice, owing to its tediousness, the difficulty of checking, etc.

Competent designers can write down with considerable accuracy the worst moments to be expected at the supports and at mid-span under any ordinary cases.

The theorem of three moments may be used in evaluating such cases, but with several spans its use is very tedious, seeing that many arrangements of loading have to be considered.

The L.C.C. rules give some moments which are fairly correct in ordinary cases.

For a full understanding some book such as Faber & Bowie's *Reinforced Concrete Design*, Vol. I. (Edward Arnold) should be consulted, where the derivation of such rules is worked out in the appendix.

Vol. II. of this work (not yet published) will, we understand, also deal very fully with this question of moments, including the effect of stiffness of columns, which is ignored in the L.C.C. rules.

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## MEMORANDA.

**Ministry of Health.**—Consequent upon the retirement of Sir James Carmichael, K.B., for reasons of health, the Housing Division of the Ministry has been reorganised and placed under the charge of Mr. E. R. Forber, C.B.E., an Assistant Secretary of the Ministry.

Mr. Forber will be assisted by Mr. R. B. Cross, O.B.E., Assistant Secretary in charge of the Administrative Branches ; Mr. Walker Smith, Director of Housing ; and Mr. Stephen Easten, Director of Production.

The work in connection with town planning and unhealthy areas will be under a separate Assistant Secretary, namely, Mr. I. G. Gibbon, C.B.E., who will also continue temporarily to be in charge of the special branch which deals with housing in London.

**New Dye Works, Perth.**—During 1919 the dye works of Messrs. Campbell were destroyed by fire, and new buildings are now going up on this site. These buildings comprise a main building, three storeys in height, with a large one-storeyed dye-house, laboratory, drying-rooms, etc., to the rear and south of the main building. The latter building is said to be the first purely reinforced concrete building in Perth, and is 220 ft. long, and 56 ft. wide.

The main features of the elevations of the building are in reinforced concrete, and exterior walls are formed in red brick panels beneath the windows. The maximum amount of daylight is provided for. On the roof there is a reinforced concrete storage tank of 78,000 gal. capacity

The architects for the building are Messrs. Smart and Stewart, of Perth, and the contractors are Messrs. Bain and Brown, of Leith. The details of the reinforced concrete work are being prepared by the Indented Bar and Concrete Engineering Co., of Queen Anne's Chambers, Westminster.

# NEW BOOKS
## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

**Structural Drafting and the Design of Details. By Carlton Thomas Bishop.**

**Chapman & Hall. 27/6 net.**

This book is exactly what is wanted to enable a student leaving college to bridge the gap between his college work and practical drawing office usefulness as a designer of steelwork.

The student is told enough about the rolling, riveting and other treatment of sections incidental to constructional work to enable him to avoid the usual college tyro design—composite sections that cannot be riveted, use of impossible sections that no one stocks, etc.

He is then shown how to draw steelwork details clearly ; not only the usual conventions as regards rivets, section lines, etc., but also standard drawing sizes, methods of filing, and all the details of a draughtsman's craft.

He is taken over the steps incidental to the design and erection of a job, the layout plan, framing plans, column schedule, etc., and has all the details of connections carefully explained and shown how to provide for them on the detail drawings.

At the end are given standard sections and properties, standard cleats, etc., all of which are of little use in England owing to the standards being different.

The book does not pretend to be a textbook on design, and there is a great deal which a student needs to know which is not given in the book. But its great value lies in the fact that what it gives is what is usually omitted, and bridges the gap between college and drawing office which the student is usually left to jump over or swim as best he can.

**Principles of Reinforced Concrete Construction. Turneaure and Maurer.**

**Chapman & Hall. 21/- net.**

This is the third edition of a well-known book, and will be welcomed. In general, the earlier editions have not been altered much, but a good deal of fresh information is given, principally in regard to flat slab (or mushroom) construction.

A careful perusal will undoubtedly give anyone an excellent introduction to reinforced concrete, and the following criticisms are not intended to lose sight of the fact the book as a whole is to be thoroughly recommended.

It is doubtful whether the pages spent on flexure formulæ for ultimate loads (p. 65 onwards), taking curves instead of straight lines for the stress diagrams in the concrete, are really useful. In spite of the fact that they are very much more complicated, these formulæ do not agree more closely with the results of experiments of beams tested to destruction than do beams calculated by the usual straight line formulæ.

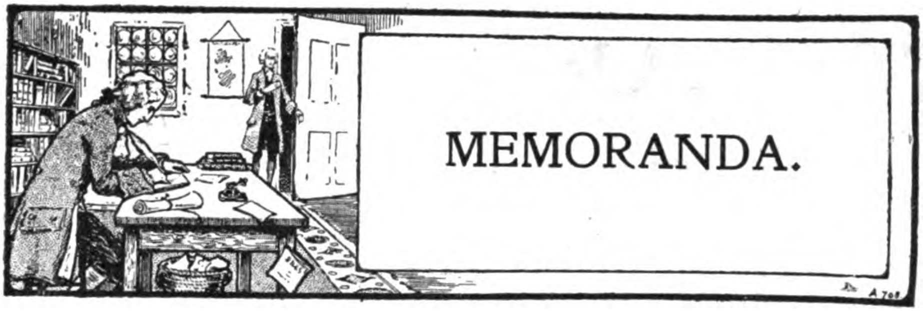
To our mind, in a book of 450 pages, more time could, with advantage, be devoted to the detailed design of beams and slabs than is given in section 235.

In this country we are not satisfied now with the recommendation given on section 218 to take $\frac{wl^2}{12}$ for moments in beams and slabs at mid-span and support for all ratios of live load to dead load.

We consider that in some cases, particularly where the live load is small, or, as in water towers, applies simultaneously to all spans, this may give results over 50 per cent. too high as regards the mid-span moments, while in other cases, as with a load principally live, with little column restraint and no appreciable width of support, the ends may be overstressed by nearly 30 per cent. These errors are so considerable as to stultify much of the accuracy of other calculations depending on these moments, and we think more accurate moment estimation necessary.

We notice on *Fig.* 32 and elsewhere that 40 lb. per sq. in. is taken for shear in concrete (by diagonal tension) and added to the resistance of bent up bars and stirrups, though it has now been made quite clear that this tensile stress in the concrete cannot exist at the same time as the high tensile stresses in the steel bent up bars or stirrups.

As the questions of shear and moments in beams form so very large part of design in practice we are sorry that we consider the treatment faulty in these matters. Otherwise the book is excellent.

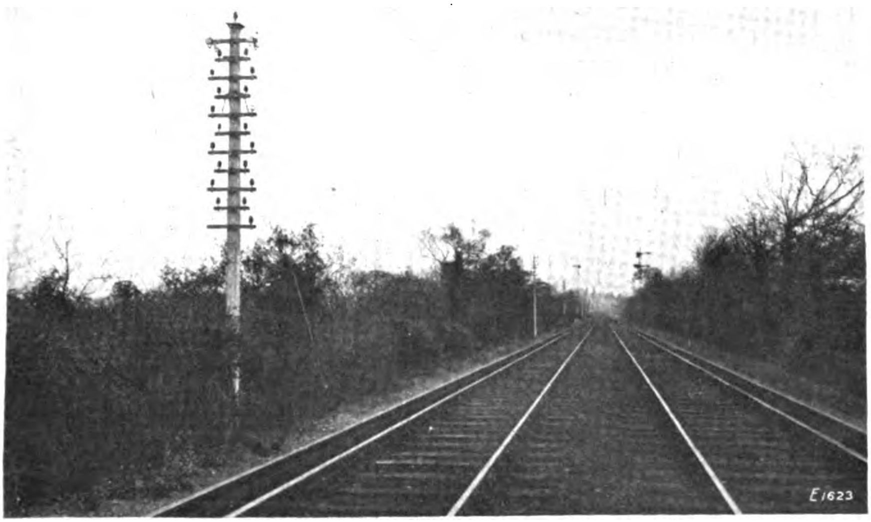


# MEMORANDA.

*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Concrete Telegraph Posts.**—The London and South Western Railway Company, like most of our important railways, have for some years past adopted extensively the use of concrete products wherever possible for the equipment of their rail track and stations. Several of these companies have their special depots where an infinite variety of concrete articles are manufactured.

The L. & S.W.R., fully up to date and abreast of the times in all its concrete work, has made, at Exeter, quite a number of reinforced-concrete telegraph posts. These have been in position by the line near Hampton Court (see illustration) for a considerable period, and so satisfactorily have they stood all conditions of weather, etc., that we understand it is now proposed to largely augment their number. The posts which have been erected are 30 ft. in length, the composition of the concrete being 2 parts of Meldon Quarry ½ in. screenings, 1½ parts of Fremington sand, and 1 part of cement, reinforced with ½ in mild round steel rods. Another fine example of concrete work done by the L. & S.W.R. are station name-boards, made entirely of concrete, even to the black lettering, which is imperishable, and they may be seen at many stations on their line.



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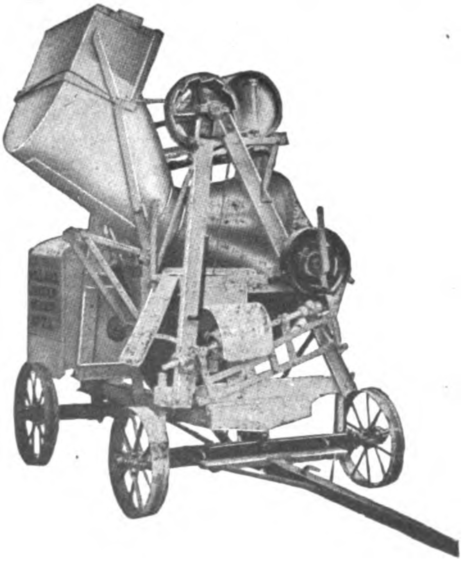

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## HOUSING NOTES.

**The Ministry of Health** (Local Housing Bonds Branch) have issued the following information:

"*Progress of Private Building.*—The National Federation of House Builders has circularised its members on the subject of the Government Subsidy Scheme, under which a free grant of £230 to £260 may be obtained by private builders for houses erected before December 31st, 1921. The circular states that representations on the part of the Federation to the Ministry of Health have resulted in many alterations which are of importance in bringing the scheme within the range of practical business. 'Those of our members who have built under the scheme,' the circular continues, 'have found that there is a market for their houses at good prices, and it is strongly urged that every member should erect a pair or two under this scheme as a trial lot.'

"Building by private enterprise continues to make excellent progress. Up to the end of July sanction to build 15,636 houses had been granted by the Ministry of Health. All these houses will, when completed, be eligible for the housing grant of £230 to £260. The total commitment to date amounts to £3,776,461. In the London district alone 3,863 houses have been approved, and may be either in course of construction or shortly to be erected. Lancashire and Cheshire have 2,184 private enterprises approved, and Yorkshire 1,291. Other districts show a proportionate number of houses to be built by private builders."

**Special Methods of House Construction.**—The Ministry of Health states that the total number of houses included in contracts which have been agreed for the provision of houses by special methods of construction is nearly 14,000, or about 17½ per cent. of all the houses included in signed contracts. About 5,800 of the houses are either in course of erection or have been completed. The method most in favour is the concrete block and slab system, and contracts for 7,430 houses of this type have been signed. Contracts have also been signed for 865 concrete *in situ* houses, 1,257 reinforced concrete houses, 3,269 steel frame and concrete houses, and 722 terra-cotta block houses. Certificates have been granted by local authorities approving plans for the erection of 1,000 "subsidy" houses by special methods of construction.

**New Garden Suburb at Hanworth.**—The Hanworth Public Utility Society is arranging to build 3,000 houses suitable for families of five or six, and all the plans are in hand for laying out a garden suburb within the next two years.

The site chosen is Hanworth Park, a beautiful Middlesex estate of 450 acres, within half an hour's run from Waterloo Station, on the Staines branch of the L. and S.W.R., and about ten minutes' walk from Feltham Station. The houses will be built of concrete blocks, and whilst everything—such as doors and chimneys—will be standardised internally, the outer appearance of the houses will be varied. They will be built in blocks of three and six, and will be spread over the estate. Each house will have a medium-sized garden. It is hoped to have the first hundred houses ready for occupation by Christmas.

## ROAD NOTES.

**Concrete Roads in Australia.**—It is reported in the *Commonwealth Engineer* that Mr. Robert F. Duncan of Messrs. Duncan & Fraser, who has recently returned from America, where he was acting under a commission granted by the South Australian Government to investigate American roads and their construction, "returned to South Australia full of enthusiasm concerning cement concrete roads and presented a report to the Government setting forth his views. He says: 'The Americans make concrete roads wherever they can; in fact, the engineer for New York State affirmed that, while he was in office he intended to get the best results from the money expended, and the only way to do it was to put down concrete roads, whatever the initial cost, because of the saving in maintenance. Many of the concrete roads in America are top-dressed, but his opinion is that top-dressing is not necessary. . . . There are in America many miles of concrete road without top dressing. It is a little noisy for iron-tyred vehicles, but it attracts the traffic every time. In America the experts are of opinion that if the money is available it pays to put down concrete.'

"Mr. Duncan gave the following interesting figures regarding costs: 'A water-bound macadam road with a daily average of 560 vehicles cost in upkeep for two years

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2s. 9½d. per super yd. This was replaced by a concrete road which immediately attracted 3,800 vehicles daily, and the maintenance cost was reduced to 1d. per super. yd. In New York State the difference between the maintenance cost of waterbound macadam and concrete was as 1,000 dollars to 100 dollars. The initial cost for a waterbound macadam road in that State was 17,000 dollars per mile, of bituminous road, 19,000 dollars; of plain concrete road, 25,000 dollars; and of reinforced concrete road, 26,200 dollars. The average life of the two first-mentioned types was about seven years, and they cost 7,000 dollars for maintenance for seven years. The concrete road lasted 30 years and cost about 3,000 dollars for maintenance for the whole period. The Americans paid great attention to the formation of the road-bed. They sank trial holes, and if there was any sign of weakness, they reinforced the concrete.'

"Discussing the suitability of concrete for use under Australian climatic conditions, Mr. Duncan said the engineers would have to decide that point. He believed concrete roads were the thing for town and country and that the day of the macadamised road has gone."

## PUBLICATIONS.

**Messrs. Mouchel & Partners, Ltd.,** of 38, Victoria Street, S.W.1, have issued a useful list of works executed on the Hennebique system of reinforced concrete, covering the period 1897 to 1919. This pamphlet, which has been compiled for the convenience of engineers and architects desirous of inspecting examples of this form of construction, has been carefully arranged and classified and contains a number of illustrations, in addition to the classified sections. The records show that 36,000 structures have been erected on the Hennebique system in all parts of the world, covering every form of engineering activity. A perusal of the figures given in the general summary will give the reader some idea of the extent to which reinforced concrete is being used, especially when it is borne in mind that these statistics refer only to the work of one firm engaged in concrete construction.

## TRADE NOTES.

**Messrs. Ransome Machinery Co. (1920), Ltd.,** 14-16, Grosvenor Gardens, S.W.1. has acquired the business, including all patents, licences, agencies, works, etc., hitherto owned and operated by Messrs. The Ransome-verMehr Machinery Co., Ltd., and Messrs. Ransomes (Tipton), Ltd. (excepting only drifting sand water filtration), The new company will carry out as expeditiously as possible all contracts that are, or may be, entrusted to it.

**Messrs. Winget Limited** have opened a branch at Sheffield (32, Norris Deakin Buildings, King Street), at which they will be pleased to answer enquiries regarding their concrete block-making machinery and allied products.

## TENDERS ACCEPTED.

### Housing.

BOGNOR.—The Bognor Urban District Council has accepted the tender of Messrs. Biswarick & Bonner, of Hove, for the erection of 54 concrete houses at £860 each.

BRANDON.—The Brandon Urban District Council has, subject to the approval of the Ministry of Health, accepted the following tenders of Messrs. Hilton & Sons, Ltd., Bishop Auckland, for the erection of steel-framed concrete, Type "B" houses:—50 houses on the Medowfield site, £950 each; 30 houses on the New Brancepeth site, £965 each; 20 houses on the Waterhouse site, £950 each.

EAST GRINSTEAD.—For the erection of twelve Class "A" houses and six Class "B" houses, the East Grinstead Urban District Council has accepted the tender of Messrs. Banger's Concrete Construction Co., Ltd., at approximately £16,800, subject to certain modifications.

HESTON AND ISLEWORTH.—The Heston and Isleworth Urban District Council has accepted the tender of Messrs. Sir Robert McAlpine & Sons for the erection of 256 houses. For the houses to be erected in concrete the price is from £851 to £1,047, as compared with £890 to £1,058 for brick houses.

HOUGHTON-LE-SPRING.—The tender of Mr. J. W. White, of Sunderland, at £850 per house, plus cost of various additional items, has been recommended for acceptance by the Houghton-le-Spring Rural District Council for the erection of 52 concrete houses.

LIVERPOOL.—The Liverpool Corporation has accepted an offer of Mr. W. W. Love, of Faversham, Kent, to erect a pair of "B" type parlour houses on the "Minniel" concrete system for demonstration purposes.

NORTHAMPTON.—The Town Council has accepted the tender of the Unit Construction Co., Ltd., for the erection of 100 concrete houses of the three-bedroom type at £1,022 per house.

SMETHWICK.—Subject to the approval of the Ministry of Health, the Smethwick Urban District Council has decided to enter into a contract with Messrs. Whitehouse & Son for the erection of fifty concrete houses on the "Dorman Long" system on a cost-plus-profit basis.

### General.

LAMBETH.—The Lambeth Borough Council has accepted the tender of Messrs. Wakeley Bros. & Co., Ltd., for the supply of a further 250 tons of Portland cement at £4 4s. 6d. per ton, delivered at Cobbett Street and Landor Road Depots, and £4 7s. 6d. per ton delivered at Romnany Road Depot.

**Lambeth.**—The Lambeth Borough Council has been recommended to accept the tender of Messrs. T. L. Smith & Co. for the supply of a " Victoria " concrete mixer, for the sum of £661 10s., less 5 per cent. discount.

**Southend-on-Sea.**—The Town Council of Southend-on-Sea has accepted the tender of Messrs. J. Ellis & Sons, of Leicester, for the supply of 345 ft. of concrete tubes, at 7s. 7d. per ft.

## CONTRACTS OPEN.

**Ellesmere.**—September 13th.—The Ellesmere Rural District Council invite tenders for the erection of 24 houses within its area. Concrete or other approved systems will be considered. Plans, etc., from the Clerk to the Council, Ellesmere, Salop. Deposit, two guineas.

**Tetbury.**—September 18th.—The Tetbury Urban District Council invite tenders for the supply of various road materials, including high-class concrete flagstones. Forms of tender from the Surveyor, Council Offices, Tetbury, Gloucester.

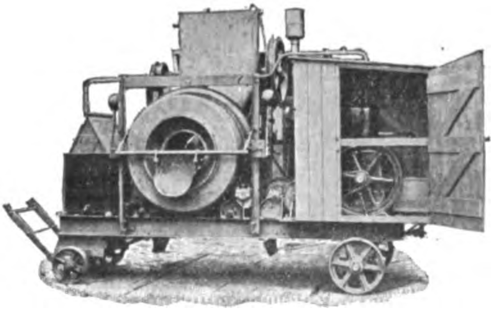
**Australia.**—September 30th.—The Manly (N.S.W.) Municipality invites tenders for the construction of an ocean pier. Messrs. Gordon & Gotch, of 15, St. Bride Street, E.C. are the London agents.

## NEW COMPANIES REGISTERED.

**Hampshire Concrete House Building Association, Ltd.** (169,173).—Registered July 21st. Blighmont Park, Millbrook, Southampton. Formed to carry on the business of building houses. Nominal capital, £3,000 in 2,000 £1 preference shares and 1,000 £1 ordinary shares. Director: W. J. Ayles, Broughton, Hants. Qualification of directors: 500 shares; remuneration to be voted.

## RECENT PATENT APPLICATIONS.

144,776 & 144,976.—J. A. A. Nystrom: Machinery for making hollow building blocks.
144,787.—J. L. Palmer and H. Melville-Smith: Interlocking blocks for building construction.
144,812.—H. J. and G. E. Clare: Cavity walls.
144,913.—C. N. Wisner: Concrete building construction.
144,975.—M. M. Smith: Concrete walls and apparatus for their construction.
104,342.—Société de Constructions Economiques: Removable reinforced concrete buildings.
145,140.—W. T. Watson, J. A. Reid and J. R. McKenzie: Hollow wall construction.
145,178.—J. Thame: Constructional steelwork.
134,811.—A. M. Cramer: Hollow building blocks.
145,806.—L. A. and A. J. Sanders: Process for forming a hardening coating on cement and concrete.
146,550.—J. F. P. Tate: Reinforced concrete construction.
146,564.—G. G. Sinclair and T. S. Inglis: Forms for concrete buildings.
146,581.—W. and W. W. R. F. Griffiths: Concrete construction.
146,605.—C. P. Lovell: Building blocks.
146,607.—A. F. Eoll: Fire proof construction.
146,645.—R. T. MacArthur: Building blocks.
146,649.—S. Day: Concrete and cement walls.
146,652.—W. Green: Building blocks.
146,671.—J. A. Calvert: Reinforced concrete beams and girders.
146,773.—W. Wilson: Concrete building blocks.
101,420.—C. Rabut: Process for facing concrete.
125,985.—H. E. Ross: Concrete buildings.
147,234.—H. A. Penelton: Concrete buildings.
147,259.—W. E. Jennings: Concrete moulds and shuttering.



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**OCTOBER 1920. VOL. XV. No. 10.**

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ISSUED MONTHLY

## CONTENTS.

**Editorials.**

**Quay Wall in Reinforced Concrete Piles & Sheet Piles at Kenitra, Morocco.**

**Concrete Cottage Building.**

**Some Reinforced Concrete Structures in Australia.**
**By E. G. STONE.**

**Two American Reports on Research Work.**

**Reinforced Concrete Work on the Continent.**

**The Largest European Concrete Vessel.**
**By V. ELMONT, B.Sc.**

**Concrete in Theory and Practice.**
**Reinforced Concrete Simply Explained. By OSCAR FABER, O.B.E., D.Sc.**

**Reinforced Concrete Rules and Regulations.**

**Questions and Answers Relating to Concrete.**

**New Books.**

**Correspondence.**

**New Methods of Construction.** **Memoranda.**

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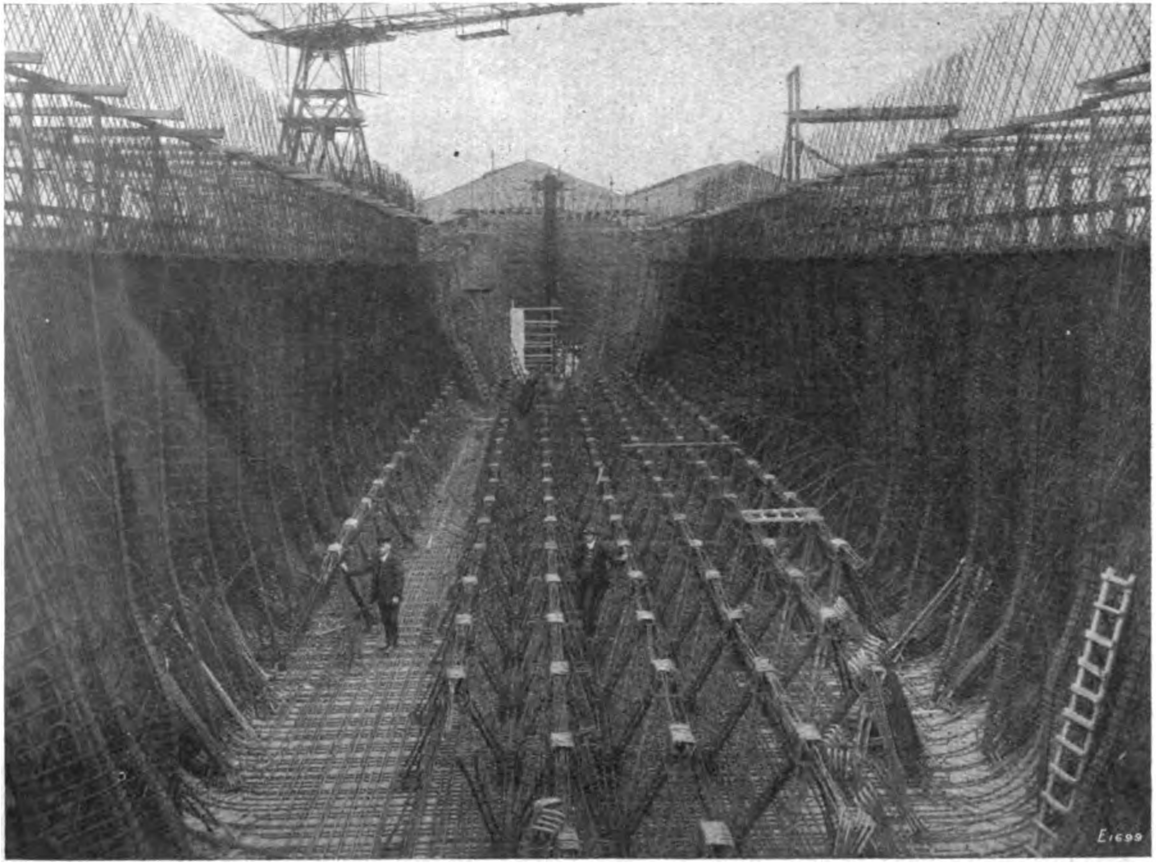

VIEW—AN 1800-TON EUROPEAN CONCRETE VESSEL
SHOWING THE REINFORCEMENT IN POSITION.
*(For description see page 696.)*

CONCRETE
AND
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Volume XV. No. 10. LONDON, OCTOBER, 1920.

# EDITORIAL NOTES.

## CONCRETE FOR HOUSE CONSTRUCTION.

IN our last issue brief reference was made to an article in a recent number of *Housing*, entitled " A Review of Special Methods of Construction," setting forth the advantages and supposed disadvantages of the various systems reviewed the latter, with two exceptions, outnumbering the former; but, with reference to concrete, so many of the statements made are likely to be misleading that they cannot be allowed to pass without challenge.

*Semi-dry Concrete.*—It is asserted that " the use of semi-dry concrete means the loss of at least 50 per cent. of its strength." There may certainly have been instances in which this was the case, but to base a general statement such as the above upon a few faulty examples is misleading in the extreme. The assertion to which we take exception could only be true when the method adopted was so entirely bad as to constitute a misuse of the material. It is a well-established fact that the amount of water required to commence hydration is small, less, in fact than is required to form a workable mixture, but if the concrete is well tamped, and kept damp until hydration is more or less complete, the result is a thoroughly sound and strong block or slab, which will compare favourably with good clay brick in both strength and absorption tests, and if the blocks are steam-cured the steam supplies all the moisture that is necessary for the concrete to attain its full strength.

While we do not, of course, advocate the adoption of the semi-dry process for all purposes, yet the efficiency of properly made concrete on this method has been proved by its use in the construction of silos, water-tanks and liquid manure tanks, where strength, density and impermeability are essential.

*Handling, Stacking, etc.*—Another of the alleged disadvantages of the use of concrete blocks and slabs is that it is " expensive, owing to repeated stacking, handling and watering." We must admit that it is news to us that concrete blocks and slabs require repeated stacking and handling. The present-day manufacturer can be trusted to eliminate all unnecessary labour, and with an up-to-date plant the products are handled three times; (1) When they leave the machine for the curing ground; (2) when they are stacked, after curing; (3) when they are transported to the site of the work; and with regard to watering, on an extensive job a revolving rose is often employed which needs but little attention.

*Bad Foundations.*—What ground there can be for the statement that concrete block construction is " not reliable on bad foundation in mining areas," we fail to understand. Since the strength of a well-made concrete block is considerably higher than that of clay brick, surely the reverse must be the case. But, further, in areas where the ground is liable to subsidence it is a common practice to erect the house on a concrete raft, and instances have been known where the whole structure has tilted over and the walls have been found to contain not a single crack.

*Cost.*—On this point it is stated that there is " very slight saving of cost, as the extra cost of labour making blocks at 2s. 1d. per hour is more expensive than making equivalent bricks by machinery and counteracts the saving in laying." This might be true if the blocks were made on obsolete methods, but the article ignores the fact that a modern concrete block machine will turn out up to 1,000 18-in. by 9-in. by 4½-in. blocks a day, which is equivalent to 6,000 bricks. Of these blocks, we have information that, on a certain job at the present time an equivalent of 650 bricks per man are being laid daily.

If there is little or no saving of cost we wonder why, at a recent Council meeting, it was decided to fix the rents of " B " class houses at 14s. for brick construction and 12s. for concrete, and of class " D " houses at 17s. 6d. brick, and 15s. concrete ; and why a London firm has reduced its offer to one Midland Corporation for building 380 cottages by nearly £40,000, undertaking to erect each dwelling in concrete at a net cost of £750, as against the average cost of brick houses at £850.

## FLAT SLAB DESIGN.

We include in this issue a résumé of the American regulations relating to so-called " flat slab " or " mushroom " constructions, being the New York City regulations *in extenso*, and a table showing how the moments to be designed for at the more important points compare in other regulations or in the opinion of various authorities.

As is well known, this type of construction consists essentially of a concrete floor in which the usual beams supporting the slab are entirely absent. The slab is carried directly by the columns, which are enlarged considerably under the slab so as to give a large support to the slab, which would otherwise punch its way down past the column, failure occurring by a combination of shear and reverse moments, both of which tend to be heavy unless a large capital is provided

The advantages of this type of construction are mainly increased headroom and absence of shadows and air pockets, owing to the elimination of beams. The construction is also in many cases considerably cheaper to construct, owing, chiefly, to the elimination of beam centering and the consequent simplification of slab centering, which now enables boards to run on their full length without cutting to waste.

There are cases in practice where the elimination of beams is by no means an advantage In many factories, for example, the beams are useful places from which shafting, etc., may be supported, and while this can be done from a flat slab by embedding suitable fittings therein, beam construction is still preferred in some cases. Clearly each case needs individual consideration.

The most remarkable thing which strikes a person unfamiliar with this construction is the smallness of the moments to be designed for at the centre of the panel.

An ordinary square panel of slab resting on four beams would be designed for $\frac{WL}{16}$ in both directions, adopting L.C.C. or Rankine, or $\frac{WL}{24}$ adopting French regulations.

No doubt these moments could be reduced considerably when the slab is continuous over all beams, but few designers would design for less than $\frac{WL}{32}$ with full continuity.

A designer accustomed to this type of design receives a kind of shock to find that in flat slab design the centre moments are taken at as low a value as $\frac{WL}{133}$, remembering that the chief difference, at first sight, lies in the elimination of the beams, which he would naturally suppose would cause the slab to require strengthening rather than the reverse.

The explanation of this discrepancy lies in the column construction. The usual slab and beam construction is designed to carry the loads to the column, without requiring the column to have great bending strength.

With flat slab construction, on the other hand, the column has to reach out into the span, so to speak, by means of its mushroom head or capital, and so greatly reduces the effective span on the one hand, and the stiffness of the column head compared to that of the slab at midspan has the effect of causing a large percentage of the total free moment to exist at the supports and a small percentage near midspan.

It is clear, however, that in the case of unequally loaded panels, the great strength of the capitals or mushrooms will not be sufficient, because the load on their edge would be unbalanced, and they would not retain their horizontal form unless the column is made capable of resisting considerable bending moments.

It is therefore specified not only that the diameter of the column head shall be ·225 (nearly a quarter) of the span, and shall slope down to the column at an angle not less steep than 45° to the horizontal, but also that the columns shall be not less than 1/15th of the span in diameter, and shall be designed for moments of $\frac{WL}{40}$, $W$ being the live load, the moment being taken partly above and partly below the floor, in proportion to the relative stiffness of the column above and the column below the floor. This estimate of column moment is of the correct order, but it would be more accurate to make it depend on the relation of slab thickness to column diameter.

The idea that columns should be designed for moments is not as generally recognised in this country as it should be and is worth drawing attention to, though the value of $\frac{WL}{40}$ should not be used in beam construction.

A large water tower was constructed for the Government Rolling Mills, Southampton, designed on the flat slab principle, and has been a great success.

Probably there are other examples, but flat slab construction has not been much used in this country, owing partly to a natural conservatism, a failure to recognise its value, a difficulty in understanding the principles underlying the design, but also largely to the building authorities not being willing to pass this construction.

It is one of the natural difficulties of legislation that it is almost bound to hinder advances of this kind, and if there were not states in which new constructions can be erected, it seems doubtful whether any great advance could ever be made in building, the authorities condemning it as untried, and the pioneer being unable therefore to try it.

We hear that the L.C.C. have not passed flat slab constructions submitted to them. Whether this is so we know not, but if it is so we think the time has come for a reconsideration and for an encouragement of a good form of construction, when in the hands of competent designers, which will do something to save the useless expenditure of English money on unnecessarily expensive construction.

## TESTS OF CONCRETE MIXTURES.

We print in this issue extracts from some reports of the Lewis Institute, in Chicago, where much research work on concrete is now in progress. One investigation deals with the effect of adding hydrated lime to cement in making concrete, a practice which has been often recommended, although with little scientific justification. The chemical questions involved in the setting of cement have received far too little attention in most testing laboratories. A chemical study shows that lime is liberated during the setting of a normal Portland cement, and it is therefore unlikely that any additional strength will be gained by adding a still further quantity of lime. On the other hand, it should be of advantage to add some substance which is capable of combining with the liberated lime to form a stable silicate, and this is the scientific reason for the success of the Romans with their lime mortars, to which they invariably added finely ground tiles, volcanic earths, or other pozzolanic materials. These substances contain silica in an active form, and unite with the lime, giving increased strength as the mortar slowly hardens. The report by Prof. Abrams bears out this reasoning. The addition of lime and of many other substances lowers the strength of the concrete, in approximate proportion to the amount added. A gain in strength was observed in one case only, that of finely ground granulated blast-furnace slag (nature and analysis not specified), and this substance is known to possess pozzolanic properties. One sentence may be quoted from the report, as it contains a moral which should be carefully noted by all who are charged with the planning of similar investigations. " It is impracticable to differentiate in all cases between the effects due to different causes, owing to the fact that in many instances two or more factors, such as mix, consistency, size of aggregate, age, etc., were varied simultaneously." It is because this practice is so common that the same investigations have to be carried out over and over again, and that it is so difficult to draw any definite conclusions from so much of the published work on concrete mixtures. There is a great need for a series of systematic and carefully planned researches.

The second report from the same source deals with the effect of the presence of tannic acid, regarded as typical of the impurities introduced into concrete by loam in imperfectly washed sand. The impurity has a very marked effect in reducing the strength. We shall also, in a succeeding issue, print the recommendations of the Institute with reference to the making of compression tests on concrete, which are now submitted for discussion. This report contains some useful notes concerning the properties of aggregates.

### A STANDARD SPECIFICATION FOR REINFORCED CONCRETE WORK.

THIS is a little pamphlet * of 19 pages, published by the Concrete Institute as a guide to Architects and Engineers in specifying reinforced concrete requirements. It opens with two pages of general conditions in which we note (clause 12) that the contractor is to pay all claims of every description. Of course, this means legally substantiated claims, but we can imagine counsel for a claimant trying to make capital out of this sweeping obligation. Under "Materials and Workmanship" the properties and tests of and upon concrete, aggregates and steel are fully gone into, but we see no mention of specific gravity of cement, a useful check on quality very easily ascertained. We think it would have been well to make these tests "provisions," for which a definite sum should be included. In large works the matter is not of much moment, but in small undertakings the cost of tests possibly required might be quite appreciable and the contractor is given no guide as to the expense to which the Architect or Engineer may put him which cannot conduce to close tendering.

Two pages are devoted to "formwork" and four to actual concreting which includes directions in the event of stoppages, frost and like contingencies. Finally, tests on the made concrete are dealt with in some detail. We commend this publication, which gives under its 128 clauses a very useful résumé of the requirements of reinforced work. Some of the clauses are alternative and of course the whole is intended to be used with such modifications as the importance or special nature of the work may demand.

### JOINTING IRON WATER PIPES WITH CEMENT.

THE use of cement in place of lead as the material for jointing the sections in cast-iron water supply pipe lines appears to be making rapid progress in America, and many long pipe lines have now been jointed by this method with entirely satisfactory results both as to the soundness of the joint and saving in cost. We learn from a Canadian contemporary, for instance, that as a result of an experiment in this direction carried out in 1917 by the Spring Valley Water Company on two sections of 4-in. cast-iron pipe, cement has now been used as the jointing material in a further 16,000 ft. of 4-in. pipe, 5,000 ft. of 6-in. pipe, and 16,000 ft. of 8-in. pipe; over one mile of these lines have been in use for more than two years under a pressure of 175 lb. without requiring any repairs, and an 18-in. pipe which is shortly to be laid is to be cement jointed. At San Jose an experimental section of 6-in. piping 70 ft. long was constructed with cement joints and tested up to a pressure of 300 lb. without any leakage through the joints. To test the strength of the joints, the 70 ft. length was raised from the ground and supported only at each end; the pipe dropped 2 ft. in the centre, but with a water pressure of 60 lb. no leakage occurred at the joints. This pipe

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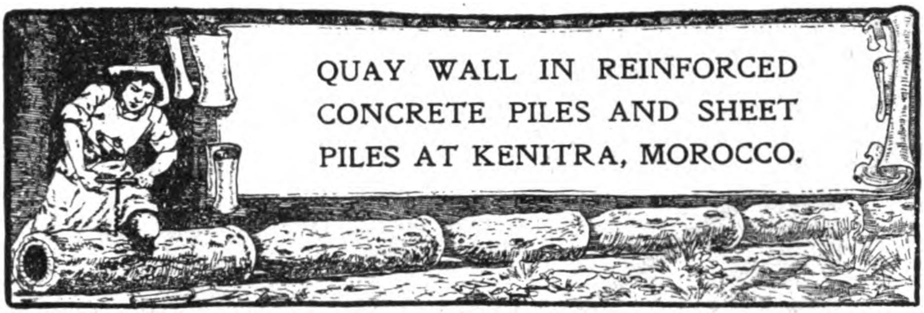
*Price 1/6 net. Concrete Institute, 296 Vauxhall Bridge Road, S.W.1.

was then emptied and left exposed to temperatures varying from 40° to 110° Fahr. for nearly a year, after which it was again filled and the joint found to be tight.

The method recommended for making the joint is as follows:—As in the case of lead joints, the spigot end is placed into the bell and two rings of jute or yarn are driven into the bell. The jute must, of course, be free from oil or tar. Neat Portland cement of a very dry consistency that will crumble in the hand (13 or 14 lb. of cement to 1 lb. of water) is then rammed into the joint as hard as possible, and this is repeated until the joint is full. In order to avoid waste of cement, a piece of canvas should be placed beneath the joint whilst it is being made, and after it is finished it should be covered with earth whilst the cement is setting. On an average it has been found that 5 lb. of cement are required for a 4-in. joint, 7 lb. for a 6-in. joint, and 9 lb. for an 8-in. joint. It is stated that when water is first turned on all the cement joints leak to a certain extent, but this practically all ceases within 24 hours, and after three days the joints are absolutely watertight.

At current prices of materials and labour in America, the relative costs of lead and cement joints are worked out as follows (in dollars per joint):—Lead: 4 in., 1·373; 6 in., 1·913; 8 in., 2·371. Cement: 4 in., 0·35; 6 in., 0·51; 8 in., 0·67. From these figures it will be seen that the use of cement effects a saving of as much as 300 per cent., and it is not to be wondered at that those who have had first-hand experience of this method are extensively using it on new schemes. In this country there will, during the next few years, be a very large amount of water supply extensions carried out in order to supply the new garden villages and housing sites which are being developed, and if anything like the same economy can be effected here by a substitution of cement for lead joints, the aggregate saving would represent a very large sum. At any rate, in the light of the experience gained across the Atlantic the subject appears to be one which should be investigated.



# QUAY WALL IN REINFORCED CONCRETE PILES AND SHEET PILES AT KENITRA, MOROCCO.

*The following is a translation of part of an article which recently appeared in "La Génie Civil."—ED.*

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Kenitra, which was a locality without any importance before the arrival of the French in Morocco, is now a flourishing town situated slightly to the north of Rabat, on the great Moroccan river, the Sabou, and at about 17 kilometres from its mouth. It is possible for ships to go up this river, so that this new town, which is not only a harbour, but also a centre of railways and roads, is likely to become further developed in the future.

In 1912 the French Government engineers constructed two timber piers, which, however, soon became insufficient.

In 1916 the Moroccan Public Works Department, under the direction of French Government engineers, decided to construct a permanent wall of a length of 1,250 m., of which 250 m. were to be carried out immediately.

This work was to be executed by a series of reinforced concrete piles driven into the ground, and united at the top by a system of beams and ties, the whole of which was to be covered by a deck. This was to be strong enough to carry moving cranes weighing 3 tons, and having a radius of 12 m. Also trains were to circulate on this deck.

Towards the end of 1916 the work was put in competition and one of the principal contractors who competed for the work thought it advisable to present an alternative scheme prepared by Mr. L. Ravier, late Engineer of the French Naval Department, in accordance with the Coignet-Ravier System of sheet piles. This scheme produced an economy of about 40 per cent. on the concrete, and 55 per cent. on the steel over and above the original scheme, and, although the former required a certain amount of filling, it was adopted. The detail plans were prepared by Mr. Ravier, in accordance with the instructions of the Public Works Department.

*Composition of the Work.*—Sheet Piles. The wall is composed (*Figs.* 3 and 4) of a row of Coignet-Ravier sheet piles, each of which has a rectangular body (pile) of 45 by 30 cm. and 12·20 m. in height. For a height of 11 m. this pile is fitted with wings or panels, having a thickness of 10 cm., giving a width of sheet pile (P.) equal to 1·24 m. The figures 1 and 2 show the manufacture of these piles.

These sheet piles are driven consecutively alongside of each other, each being guided by the neighbouring pile by means of pieces of wood bolted to the edge of the wing, and which form a guide engaging at the top of the wing and gradually following down as the pile is being driven.

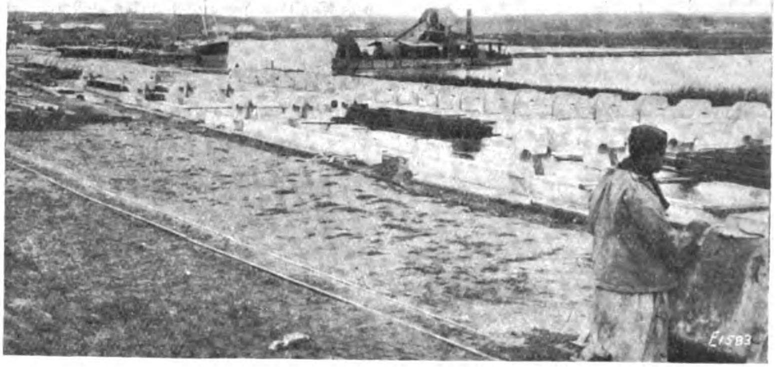

FIG. 1. GENERAL VIEW OF SILO, SHOWING COIGNET-RAVIER PILES MATURING.

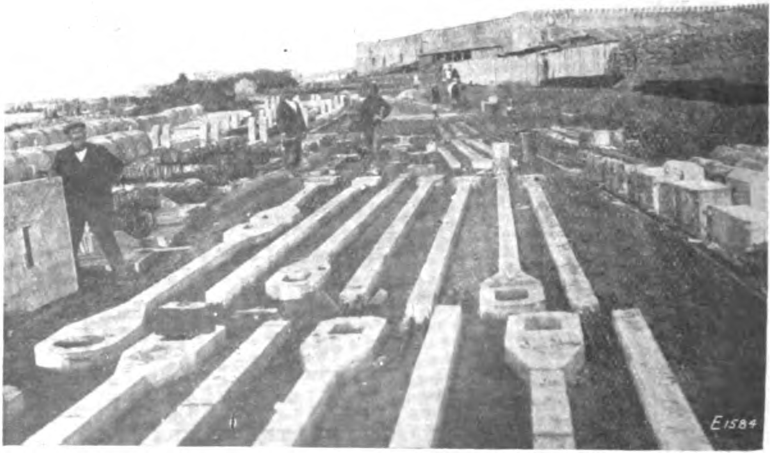

FIG. 2. LAND TIES AND ANCHOR PLATES READY FOR USE.

This system does not necessitate that the piles should be driven to a set. It simply forms a wall sufficient to resist horizontal pressure, but only calculated to support slight vertical pressures.

The length to which the piles are to be driven was first fixed by means of timber test piles. This length was chosen slightly less than that required for a perfect set, but sufficient, however, to fix the piles into the ground in a solid manner, so that they may stand upright during the execution of the work. It is easy, therefore, to regulate the driving of all the piles to the same level. The stability of the wall is ensured by means of land ties and anchor plates.

The section of the reinforcement of the sheet piles was determined in such a manner as to give them the necessary amount of resistance to bending. The wall was, therefore, calculated as a vertical reinforced concrete floor in which the horizontal pressure, due to the filling, takes the place of the superload on the floor, the wings of the sheet piles acting as floor slabs and the piles as beams. The joints of the land ties act, of course, as points of support. The calculations were made in accordance with the rules of Mr. Resal, General Inspector of Roads and Bridges, and in accordance with the French Regulations of 1906 for reinforced concrete.

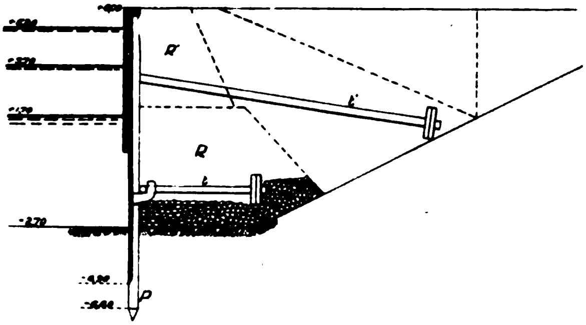

FIG. 3.

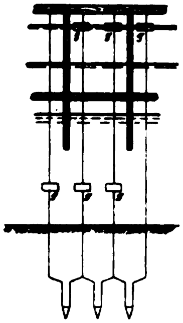

FIG. 4.

A filling composed of stones (*Fig.* 3) R, $R^1$, was placed immediately at the back of the wall to a thickness of about 8 m. at the base, and 2 m. at the top. The dotted lines indicate the various fillings. The filling composed of stones has allowed the thrust to be calculated with a slope of 45 degrees above the water and 40 degrees below the water level. This has had the effect of reducing the efforts, and, consequently, has produced an economy in the reinforced concrete, at the same time as producing better conditions of stability.

As this work was constructed on mud, it has been necessary to take into account, in the portion of the piles below the dredged level, that relatively much greater pressure would be exerted corresponding to a slope of only 20 degrees.

*Methods of Anchorage.*—Each sheet pile is maintained in its height by two steel land ties, *t*, $t^1$, surrounded with concrete. These unite the sheet pile to the anchor plates in reinforced concrete, the latter being simply placed freely in position and resting on the slope of the ground, and afterwards surrounded with filling. The lower tie *t* is fixed to the sheet pile by means of a pivot in reinforced concrete running through its thickness and by means of which it is attached to two hooks in reinforced concrete supported by the sheet pile, the whole of which forms an articulation which allows the tie to hook properly, and, at the same time, to take the required inclination, in accordance with the slope of the ground on which the anchor plate is resting at its other extremity. The fixing of the pivot to the hooks is made below low water level.

Concerning the fixing of the higher land tie, which is above water level, a semi-articulation has been used, in accordance with the type usually employed by Mr. Mesnager, Chief Engineer of Roads and Bridges—namely, by means of a flattened tie, in order that flexion should take place easily.

*Execution of the Work.*—The sheet piles at Kenitra weighed about 6 tons each and were driven by means of an American pile driver, the monkey of which weighed 1,500 k.g. This pile driver was fitted with a steel winch and on a pontoon against which barges loaded with piles could be moored. The guiding of the piles, which was done by means of wooden guides, fixed temporarily to the edge of the wings, offered no difficulty.

After the driving of the piles, the lower ties were placed in position, and afterwards the lower part of the stone filling was carried out. By lowering the ties along the projection at the back of the sheet piles it was possible to hook them automatically to the reinforced concrete hooks provided for the purpose. The stone filling prevented the ties from getting out of position. Once the lower ties were in position, the filling was completed methodically by first loading up the anchor slabs of the lower ties, then gradually filling up at the back of the wall.

The next operation consisted of placing in position the upper ties at low tide. After this the articulations of the Mesnager type uniting the ends of the ties to the sheet piles were carried out. After these ties had been fixed the remainder of the filling was executed as previously. Finally, the remainder of the filling was placed in position. To finish the work the top of the sheet piles were united by means of a continuous beam in reinforced concrete. No attempt was made to make the joints water-tight. In fact, weep holes were left in the wall in order to prevent an accumulation of water at the back of the wall, and in order to reduce the pressure.

The quay wall was completed by means of timber fenders fixed in a suitable position.

Once the work was terminated, it was tested on December 4th, 1918, on a length of 60 m. by means of a superload of sand weighing 3,000 k.g. per square metre, and the results were found to be absolutely satisfactory. Since then the work has been in continuous use.

*Conclusion.*—This method of construction, which has produced an economy of 40 per cent. for the concrete and over 50 per cent. for the steel, as compared with a reinforced concrete deck supported on piles, is also productive of a similar economy as compared to a wall in ordinary piles and sheet piles constructed in reinforced concrete.

The economy, so far as the concrete is concerned, is due to the use of T-sections, which produce the same resistance with very much less concrete than sheet piles of constant thickness throughout their height. The economy of the steel may be attributed to the fact that the arrangement of the anchor ties constitutes an important point in the system of construction, as it produces several points of support throughout the height even below water, which has the effect of considerably reducing the bending moments which have to be taken by the vertical elements of the work.

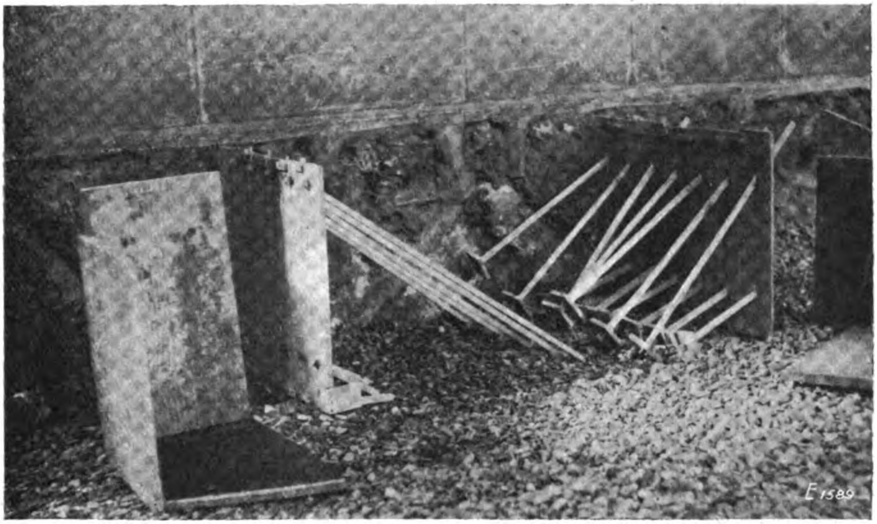

Fig. 5. Coignet-Ravier Models of Walls with different Methods of Anchorage which were tested.

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## MEMORANDUM.

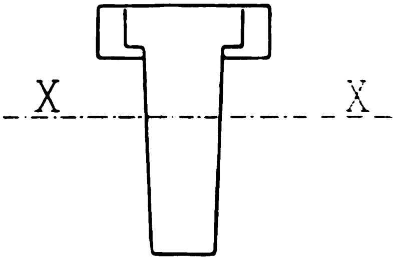
**New Bridge at Shanghai.**—Traffic movements in Shanghai are made very difficult by the wooden bridge over the Soochow Creek, which is almost constantly under repair. It is now proposed to replace this old structure by a three-span cantilever bridge constructed of reinforced concrete with the suspended span of steel. The total length of the central span will be 120 ft., and the side spans will each be approximately 56 ft. long. A clearance of 12 ft. at high tide is to be provided in the middle of the centre span, and must be very little reduced for a width of 40 ft. on either side of the centre. To obtain this clearance it will be necessary to use a grade of 1 in 25 for the roadway. The carriage-way will be 36 ft. wide and the footways 10 ft. each, giving a total width of 56 ft., compared with a total width of 50 ft. in the old bridge. The bridge is designed to carry a 14-ton steam roller, together with steel cars, and a uniform live load of 100 lb. per sq. ft. In order that the centre line of piers shall conform with the direction of the current the centre line of the bridge will have an angle of " skew " of 14 deg. The total cost of the bridge, inclusive of work required to be done on piers, cofferdams, abutments, and approaches, is estimated at 121,980 taels—say about £30,000.—*The Engineer.*

# CONCRETE COTTAGE BUILDING.

## HOUSES AT UXBRIDGE.

THE first patent system of construction to be approved by the Ministry of Health was that of Captain A. S. Adams, who formed a syndicate known as the Adams Housing Syndicate Limited, of which Captain Adams is the managing director.

Specimen buildings carried out by this system are now completed at Uxbridge, close to the main road and near the boundary of Middlesex and Buckinghamshire. The whole of the materials used for the construction of these buildings is made at the works at Uxbridge, where plant has been installed for the manufacture of the special parts upon which the principle of the system is based. The system comprises a framework of hollow steel sections, specially rolled, and filled with concrete, the panels between the framework being of the usual concrete block hollow wall type, the outer skin being 2 in. thick. These blocks are cast in moulds and made wet. The air cavity is 4 in.



The foundations are built in the usual method and the walls are constructed solid with concrete blocks to damp proof course level. These blocks are manufactured with hand grips to facilitate handling, and are laid in cement mortar. Above this level the whole of the building is framed up of plates, stanchions, floor and ceiling joists, and sometimes rafters with the standard patent hollow steel sections which constitute one of the features of the system. These steel sections are of special design and are formed with the idea of combining the maximum amount of rigidity and strength for the minimum weight of steel employed.

The following figures compare the Adams Housing Syndicate sections with solid sections.

The moment of inertia of the A.H.S. section about the axis X.X. is 1·6 and the area in the metal in the section is ·875 sq. in. A solid **T** bar with an area of ·875—viz., 2 in. by 1½ in. by ¼ in.—has a moment of inertia of only 0·16 (10 per cent. of the A.H.S. section), whilst a 2 in. by 2 in. by ¼ in. which has an area of 1·05 sq. in. (or 13 per cent. heavier) has a moment of inertia of 0·38 or only 23·75 per cent. of that of the A.H.S. section. The moment of inertia of the A.H.S. section is

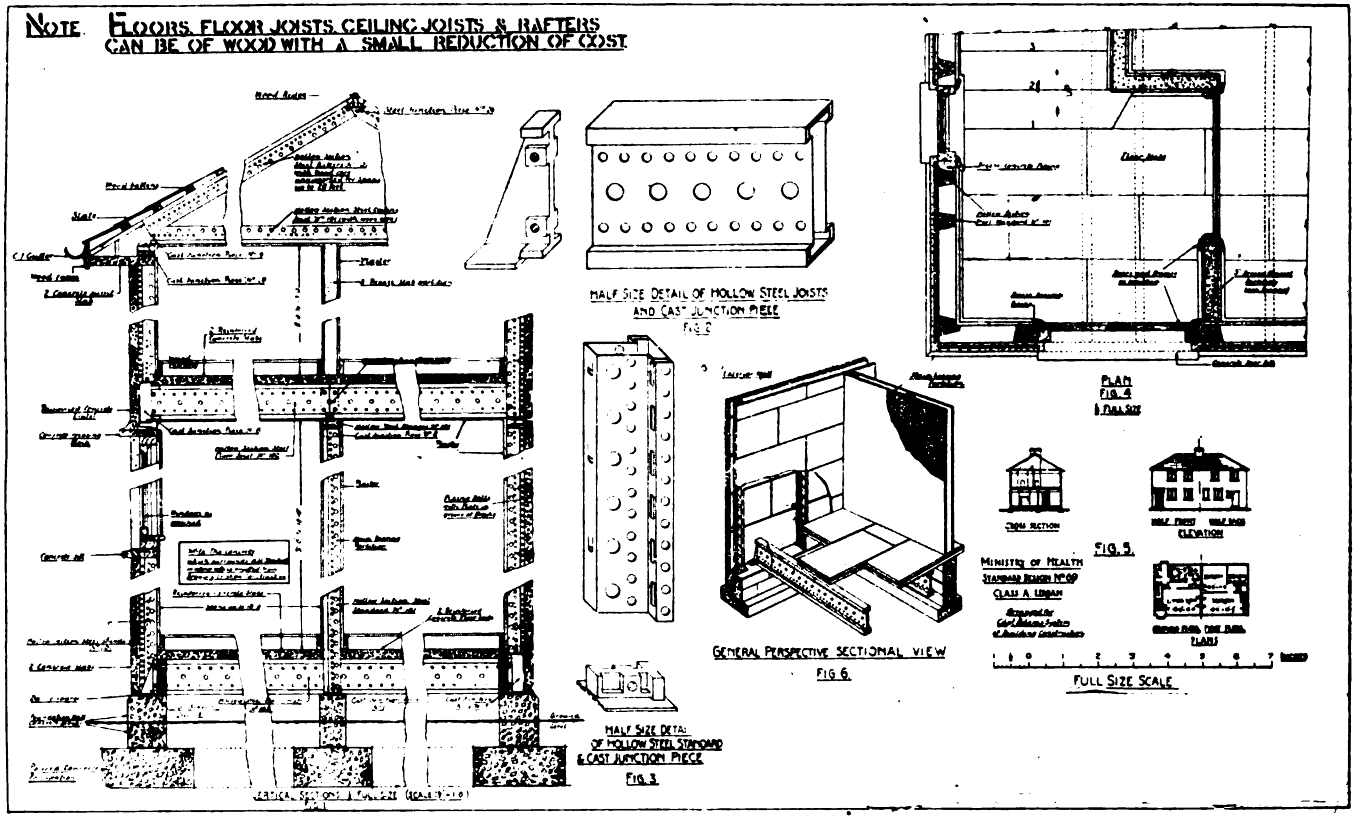

NOTE. FLOORS, FLOOR JOISTS, CEILING JOISTS & RAFTERS CAN BE OF WOOD WITH A SMALL REDUCTION OF COST.
Slate
C.I. Gutter
Plaster
HALF SIZE DETAIL OF HOLLOW STEEL JOISTS AND CAST JUNCTION PIECE
FIG. 2
HALF SIZE DETAIL OF HOLLOW STEEL STANDARD & CAST JUNCTION PIECE
FIG. 3
PLAN
FIG. 4
½ FULL SIZE
GENERAL PERSPECTIVE SECTIONAL VIEW
FIG. 6
CROSS SECTION
HALF FRONT HALF BACK
ELEVATION
FIG. 5
MINISTRY OF HEALTH
STANDARD DESIGN No 09
CLASS A. URBAN
GROUND FLOOR, FIRST FLOOR
PLANS
0 1 2 3 4 5 6 7 INCHES
FULL SIZE SCALE
VERTICAL SECTIONS ½ FULL SIZE

Fig. 1. Showing Details of Construction.

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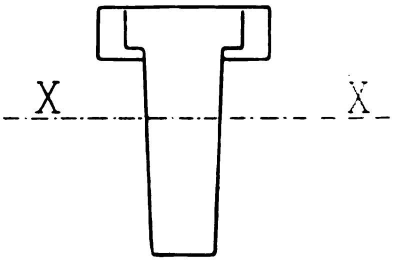

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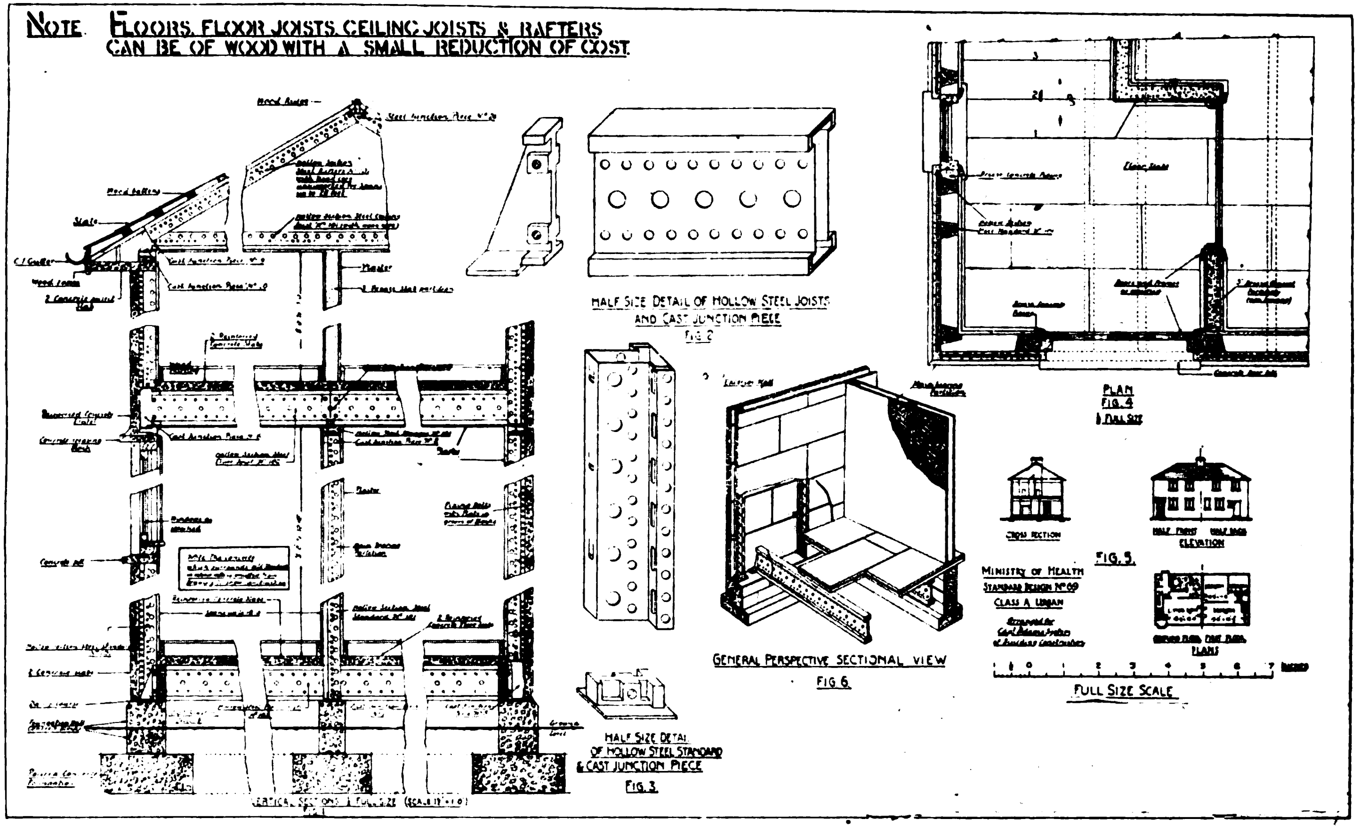

NOTE. FLOORS, FLOOR JOISTS, CEILING JOISTS & RAFTERS CAN BE OF WOOD WITH A SMALL REDUCTION OF COST.
Wood Ridge
Wood battens
Slate
C.I Gutter
Plaster
Concrete sill
VERTICAL SECTIONS ½ FULL SIZE (SCALE 1"=1·0")
HALF SIZE DETAIL OF HOLLOW STEEL JOISTS AND CAST JUNCTION PIECE
FIG. 2
HALF SIZE DETAIL OF HOLLOW STEEL STANDARD & CAST JUNCTION PIECE
FIG. 3
GENERAL PERSPECTIVE SECTIONAL VIEW
FIG. 6
PLAN
FIG. 4
½ FULL SIZE
CROSS SECTION
HALF FRONT HALF BACK
ELEVATION
FIG. 5.
GROUND FLOOR FIRST FLOOR
PLANS
MINISTRY OF HEALTH
STANDARD DESIGN Nº 69
CLASS A URBAN
FULL SIZE SCALE
0 1 2 3 4 5 6 7 INCHES

Fig. 1. Showing Details of Construction.

equal to that of 3 in. by 3 in. by $\frac{5}{16}$ in. T. The weight of this latter is just double that of the A.H.S. section of equal moment of inertia.

These sections are perforated in such a manner as to take all electric wires, pipes, etc., and the perforations are so arranged that joints or junctions between the different members can be made at any point. The joints are effected by means of special standardised cast-iron junction pieces. The steel sections are protected against corrosion, where they occur in the outer walls, by being embedded in concrete: they are furthermore filled with concrete. Where the sections occur in the inner walls of the building they are effectively protected from corrosion by a special coating of anti-rust material. This coating is applied by heating the steel and dipping it.

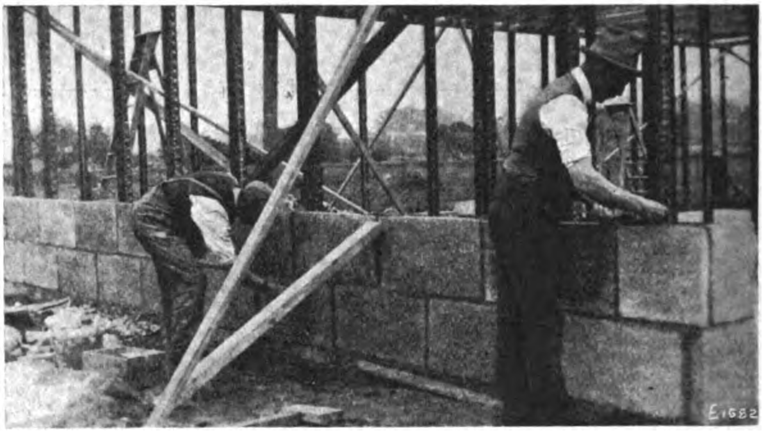


Fig. 2.

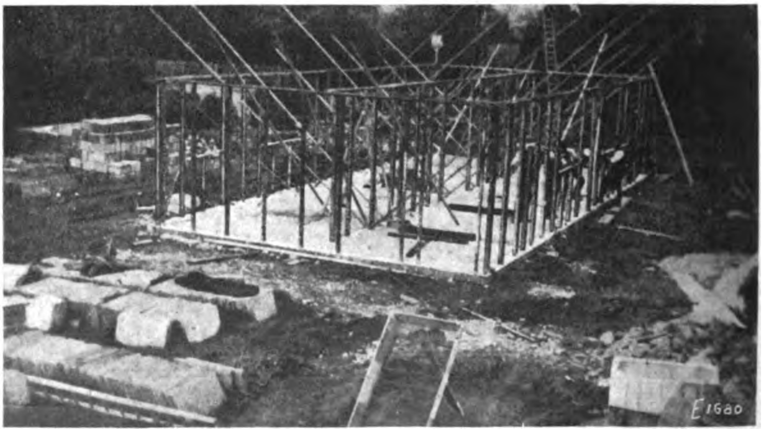


Fig. 3.
CONCRETE HOUSES AT UXBRIDGE.

Cast iron shoes are built on to the solid concrete wall and into these the uprights are fixed. The exterior face of the wall is then built up with pre-cast concrete slabs which have a groove on all edges. The original method of attaching the wall to the stanchions was to fit an iron plate, drilled to take a bolt which passed through the upright, into one of the grooves. This method has now been superseded, and a clip is used which fits into the groove and also round the flange of the upright. The blocks are cast with a special weather resisting rough-cast surface and after erection the joints are raked out and filled with similar rough casting so that the finished surface has the appearance of the ordinary rough-cast of fine texture. Concrete or wood sills are built into door and window openings, and concrete lintels, reinforced where necessary, are employed.

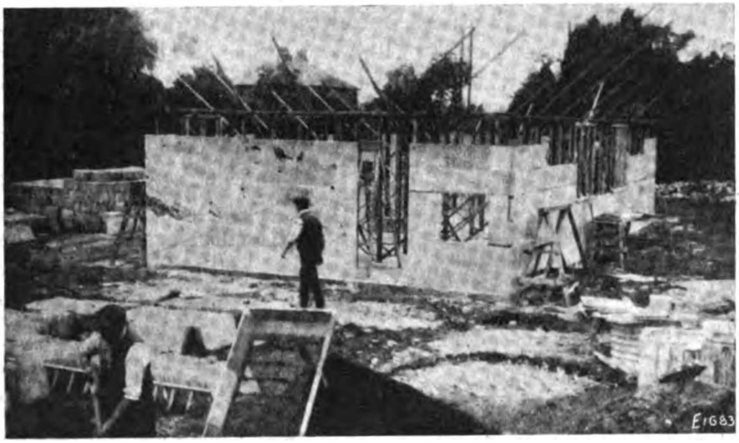


Fig. 4.

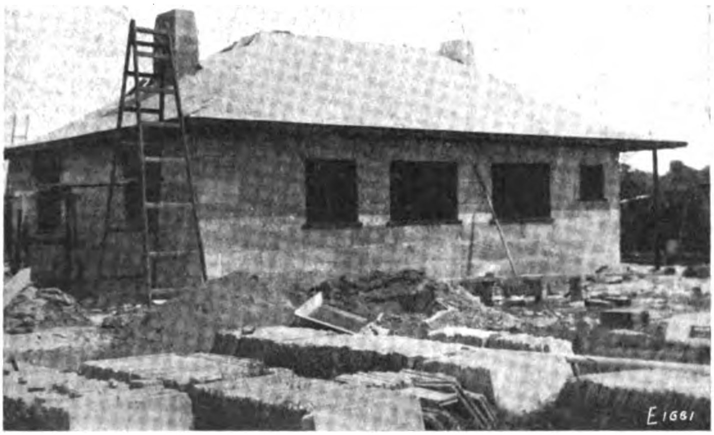


Fig. 5.
CONCRETE HOUSES AT UXBRIDGE.

Bearing partitions are constructed with the steel framing similar to the exterior walls and covered on each side with expanded metal lathing and plastered nonbearing partitions are of clinker slabs plastered on both sides. Party walls are built either 9 in. solid or similarly to the outer walls. The ceilings are of fibrous plaster fixed to the ceiling joists.

The floors are formed by laying to half bond 2-in. reinforced grooved edged concrete slabs on the steel floor joists and jointing them with Portland cement mortar. They are fixed to the steel joists in the same manner as are the wall slabs to the uprights. These floors can be covered with any mastic floor finish, or wood floors can be used if desired. The roof is constructed of the hollow steel sections and cast-iron junction pieces. A wooden ridge is used and a wood core is fixed in the rafters, to which are nailed battens or boarding. Where the span exceeds 25 ft. steel purlins and struts are used. Alternatively the roof can be constructed throughout of timber in the usual manner. Hips and valleys are formed of a deep hollow steel section. The chimneys are of brick. The whole system of construction is clearly shown in *Fig.* 1, while *Figs.* 2 to 5 show the bungalow, which was the first building to be finished, in various stages of completion.

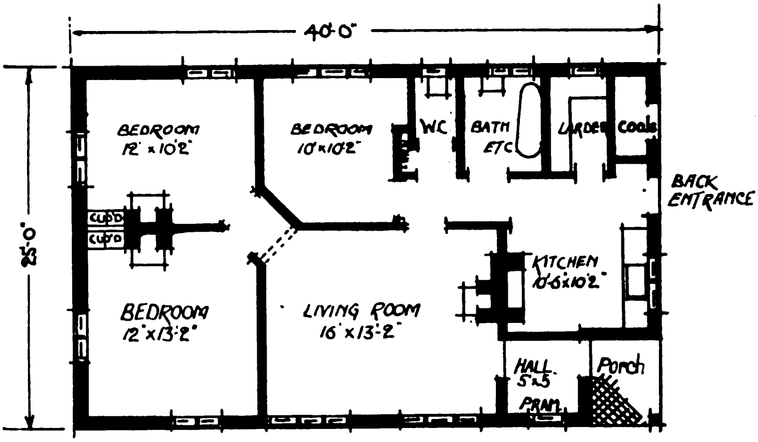
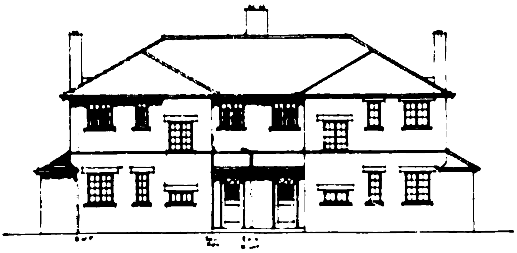


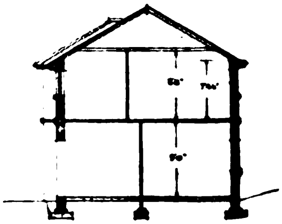
FIG. 6. PLAN OF BUNGALOW AT UXBRIDGE.

## HOUSES AT SOUTHPORT.

THE plans of some cottages which are in course of erection at Southport are shown in *Figs.* 6 and 7. The system is that of the Unit Construction Co., Ltd., who, it will be remembered, built a number of houses at Braintree in Essex. The system was very fully described in these columns in our issues of May and



FRONT ELEVATION.



CROSS SECTION.

November, 1919, and it is not proposed to repeat the information then given. It will be noticed, however, that the flat roof which constituted a subject for so much controversy has here been abandoned, and we feel bound to say that the appearance of the houses gains considerately by the introduction of the pitched roof. An attempt was also made to utilise the metric system and adopt a unit of the metre. The unit for these cottages is 1 yard.

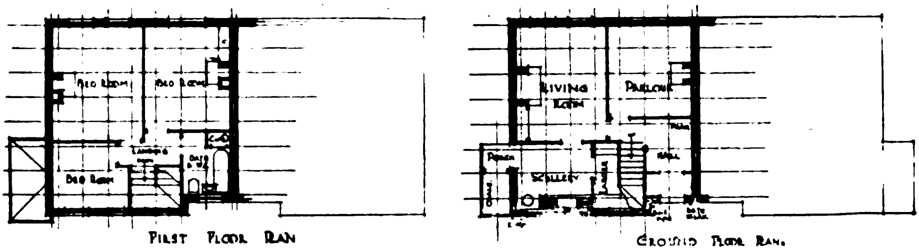


Fig. 6. Houses at Southport.

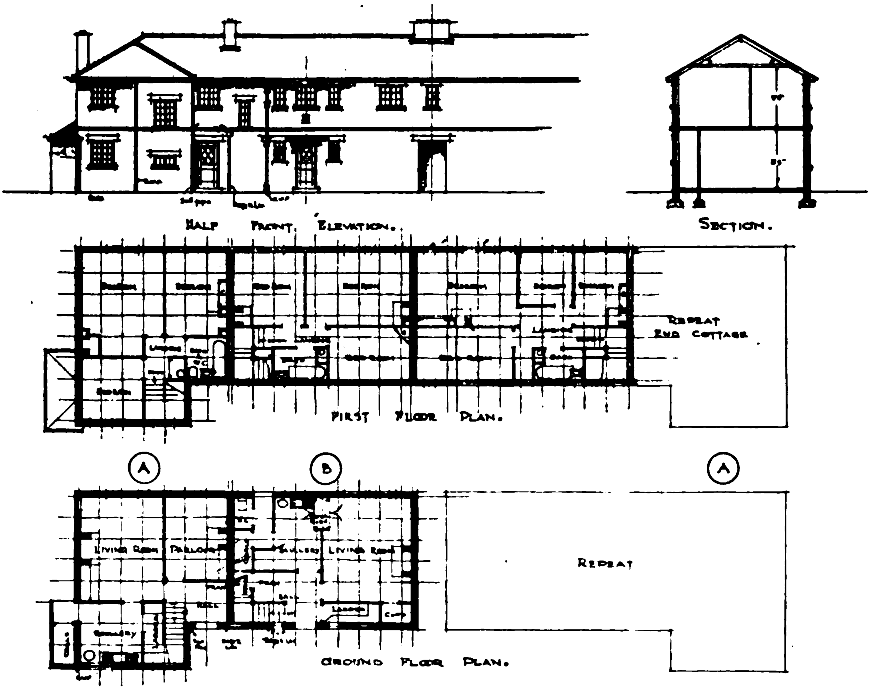


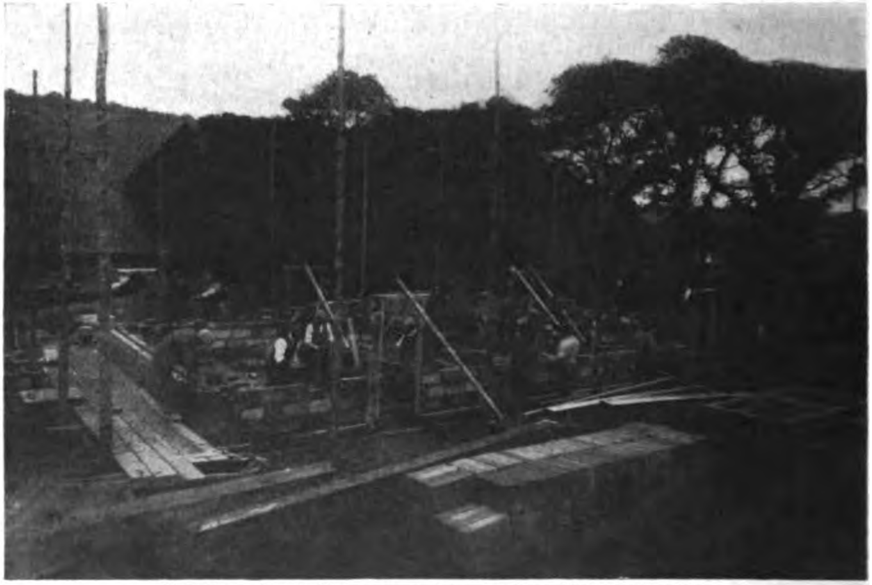
Fig. 7. Houses at Southport.

# A HOUSING SCHEME, BRIGHTON.

*The advantage of substituting concrete for bricks has been shown in an interesting manner in a housing scheme now in progress at Brighton, of which we give some particulars and illustrations below.—ED.*

BRIGHTON, like every other town, has been in urgent need of houses ever since the war. The few blocks of cottages erected here and there have only served to accentuate the demand. The Corporation have now embarked on a scheme with a view to alleviating the shortage of housing accommodation.

No healthier site could have been found than the slopes of the Moulscombe estate, where the South Downs drop gently into the northern outskirts of the town. The population of the district has increased abnormally in recent years, chiefly as a result of the war, for it was near Moulscombe that the great Oppenheimer diamond-polishing factory was started for limbless and other soldiers invalided out of the Army. Some two or three thousand ex-soldiers are now working in this factory.



THE FIRST DAY'S WORK ON AN EXPERIMENTAL PAIR OF HOUSES.

The present scheme comprises 478 houses of types known as "Class A" (with three bedrooms) and "Class B" (with four bedrooms). The work has been divided into four sections and designed by local architects. The architects for Section 1 are Messrs. Clayton and Black; Section 2 Mr. Thomas Garrett; Section 3 Mr. W. H. Overton; and Section 4 Mr. E. Wallis Long; with Professor Adshead as adviser.

The following are the sizes of the rooms in one of the type "A" houses:—

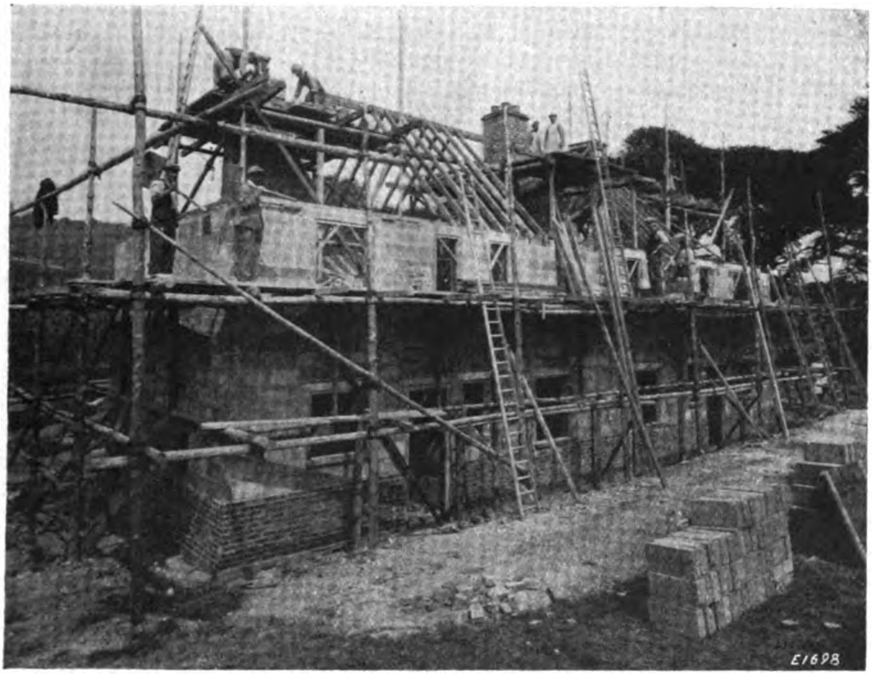
Living room, 17 ft. by 11 ft.; Scullery, 12 ft. by 7 ft.; Parlour, 12 ft. by 10 ft.; and three Bedrooms, respectively 13 ft. 9 in. by 8 ft. 6 in., 11 ft. 3 in. by 11 ft. 3 in., 9 ft. 10 in. by 12 ft. 3 in.

All the principal rooms have casement windows, with hopper ventilators and fire places. The bathroom (with a lavatory basin and hot and cold water) is within easy access of the bedrooms. Cupboards have been provided in all bedrooms, dressers in all kitchens; and deep sinks in all sculleries, with plugs and hot and cold water, so that they can be used for washing purposes as well as for washing up. Gas cookers can easily be installed in all houses if desired, and there will be electric light throughout.

In its earlier stages the scheme was largely due to the indefatigable efforts of Major Clements, Housing Surveyor for Brighton, who has since joined the Ministry of Transport, and the work is now being carried out by Mr. H. Tillstone, Borough Surveyor. The total cost of the houses will be about £400,000, the price per house not to exceed approximately £930.

The contract was given to Messrs. A. & S. Wheater, of London and Birmingham, whose agent at Brighton is Mr. E. Dicker, and was signed on the 3rd of June last.

All the houses are being erected on the continuous cavity system. The original scheme was to build the whole of the internal walls with bricks. The bricks, however, proved to be a serious stumbling-block to the economical development and rapid progress of the work, and it was decided, very early in the operations, to complete most of the houses in concrete blocks alone. At the present date the contractors have not only dug and concreted the foundations of the whole of the 478 houses, but in the case of 300 houses the work is proceeding with great rapidity, some fifty or more being already erected up to first-floor level and a few roofed in.

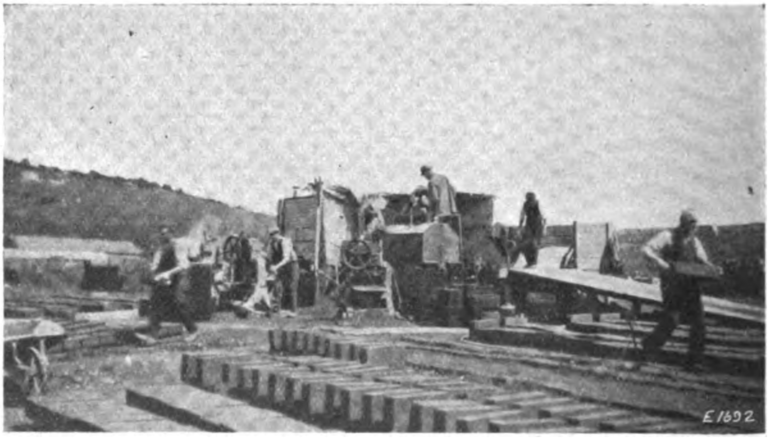


Eighth Day's Work on an Experimental Pair of Houses.

The organisation on the whole of the work is a point of special interest in this scheme. The concrete blocks and slabs are being made on Winget "pressure" machines, three depots having been organised on the site, each depot comprising three block-making machines, which are served with concrete from a Winget Chain Spade Mixer. Twenty-four men, with a foreman, are turning out an average 4,500 blocks per eight-hour day, and since each block is equivalent to six bricks, this means a weekly output from these three units equal to 150,000 bricks. The contractors point out that the initial outlay on plants of this description is negligible as compared with the cost of brickworks producing the same amount.

The blocks are made as wet as possible: the contractors find that by using concrete that is really semi-wet—"as wet as it can be made to leave the machine"—they avoid the subsequent necessity of watering blocks after manufacture. After the blocks have hardened, they are at once carted away and stacked in front of the particular job allotted to them, ready for immediate use. This clears the way for another day's output, and the need for a large stacking-ground is avoided.

As stated earlier in the article, such brickwork as was proposed was abandoned at a very early stage of the work in favour of concrete blocks, owing to the difficulty in obtaining sufficient bricklayers and the fact that the houses were costing more than was necessary. The concrete blocks, on the internal walls, were so satisfactory from the point of view of speed and economy that it was decided to experiment with a pair of houses built entirely of concrete blocks, excepting for the base, which was left with the brick facing. These two experimental houses were commenced towards the end of July, and built, ready for inspection, by August 10th. As a result of this experiment it was decided to continue the scheme completely in concrete blocks, and where the houses were partially erected in bricks, to finish these also in blocks and rough-cast them all over, leaving nothing to show on the face where the bricks ceased and the blocks commenced.



Concrete Blockmaking at one of the Depots.

An economy of 12 to 15 per cent. has been effected at Moulscombe in the manufacture of concrete blocks as against the cost of bricks, and this in spite of the fact that the clinker used as aggregate for the blocks had to be brought from the Corporation Electricity Works some six miles away. Thus the aggregate has cost more than would be the case under average conditions.

The comparative prices for the completed houses are not yet available, but the following figures are interesting regarding the cost of building the experimental blocks of two houses above ground-floor level:—

| | £ | s. | d. |
|---|---|---|---|
| Inner and outer leaves of concrete blocks, including rough casting and partitions on first floor, per pair .. .. .. .. | 114 | 15 | 0 |
| Outer leaf in brick and inner leaf in concrete blocks, including pointing and partitions on first floor, per pair .. .. .. | 146 | 18 | 0 |

representing a saving of roughly £32 on each pair of houses on labour alone, in addition to which there was a saving of £16 on the cost of the concrete blocks as against the cost of bricks.

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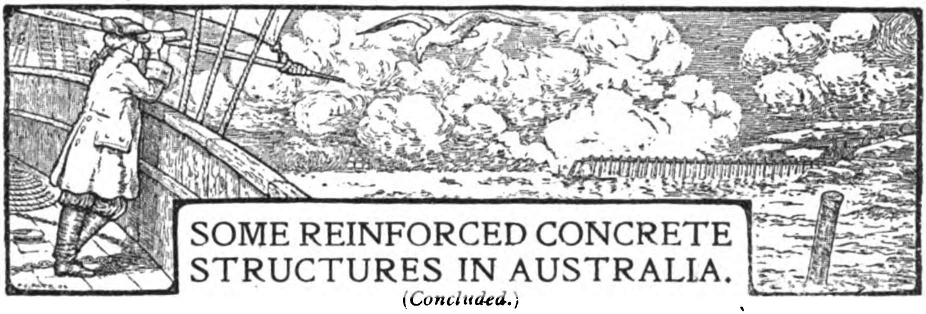


# SOME REINFORCED CONCRETE STRUCTURES IN AUSTRALIA.

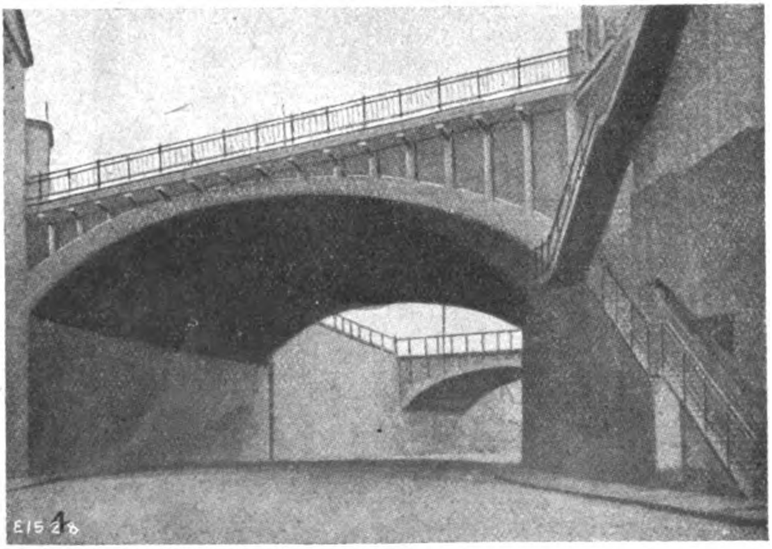
*(Concluded.)*

By E. G. STONE, Reinforced Concrete Specialist and Consulting Engineer, Adelaide.

*In a recent number of the "Commonwealth Engineer," Mr E. G. Stone gives an interesting account of some of the reinforced concrete structural undertakings carried out in Australia under his supervision, and we are reproducing Mr. Stone's article and some of the illustrations from the above-mentioned journal, and in this issue we reproduce the remainder of Mr. Stone's article.—ED.*

## THREE 90 FT. ARCH BRIDGES OVER ARGYLE CUT, SYDNEY.

THESE bridges, which were built for the Sydney Harbour Trust, were designed upon an adaptation of Reuterdahl's theory. The engineer-in-chief of the trust, Mr. H. D. Walsh, M.Inst.C.E., required the structures to stand heavy point or concentrated loads, such as would be met with in heavy ordnance passing over the same. The thickness at the crown was 27 in. to 36 in. at the springing, the reinforcement of rods 1 in. diameter, spaced in the first bridge 3½ in. centres; for the last two the spacing is only 4½ in. and 5 in. centres respectively. The cross reinforcements are ⅜ in. diam. rods, spaced about 18 in. centres, zig-zag. No expansion joints are allowed for in the arch ring, the structure being designed as an elastic arch. The spandril walls, however, have two vertical joints filled with bitumen for expansion.

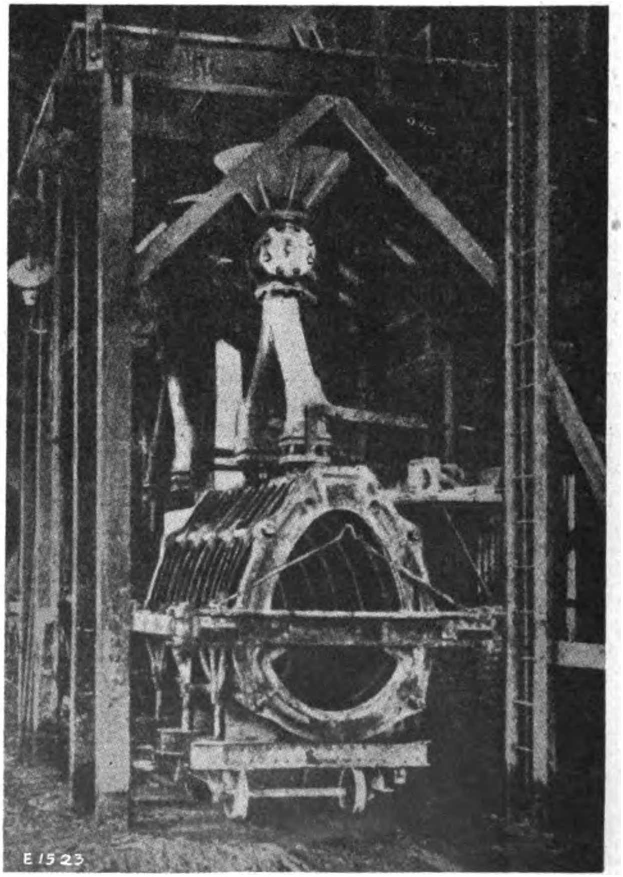


*From the "Commonwealth Engineer."*]

REINFORCED CONCRETE ARCH BRIDGE, ARGYLE CUT, SYDNEY.

### MAIN SEWERAGE WORK.

The sewerage scheme installed by the Geelong, Vic., Water and Sewerage Trust embraces several leading features in reinforced concrete work. As it was necessary to cross the river Barwon and river flats with the sewer line a reinforced concrete aqueduct, 2,424 ft. long, comprising 13 spans of 176 ft., and one of 136 ft., was constructed. A description of the aqueduct, which was constructed on the cantilever principle and designed and built by Mr. E. G. Stone, has been previously illustrated and shortly described in *Concrete & Constructional Engineering*, January, 1916, p. 49.

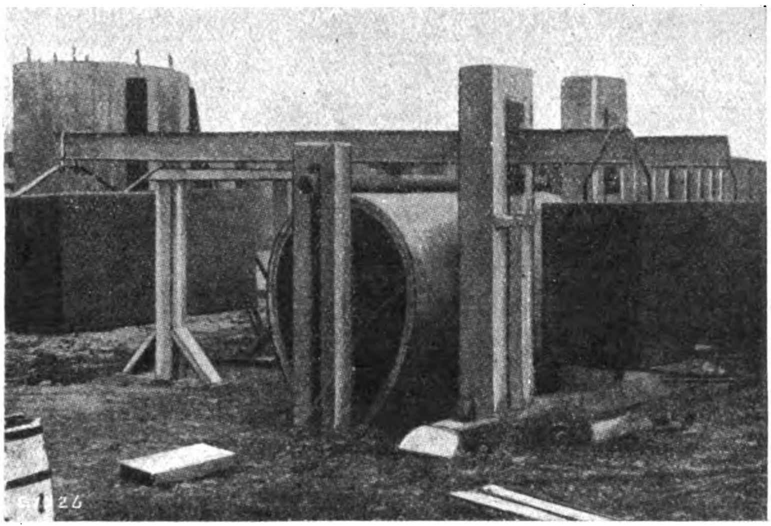


*From the "Commonwealth Engineer."*]

CONCRETE RECEIVER FOR PIPE MOULDS, SEWERAGE WORKS, GEELONG, VICTORIA.

The writer patented for this work a new system of making reinforced concrete pipes. Strong moulds of steel plate were built on wheels. These were brought, after erection, with reinforcement in them, under the receiver, which was filled by machine-mixed concrete. Compressed air was applied, and then concrete deposited under a pressure of 70 lb. per sq. in. Special ventilating holes were introduced, and all surplus water that had to be used in mixing to get a thin mixture was pressed out of the concrete. With this method the pipes could be handled within six hours after casting. All the work was done in organised steps.

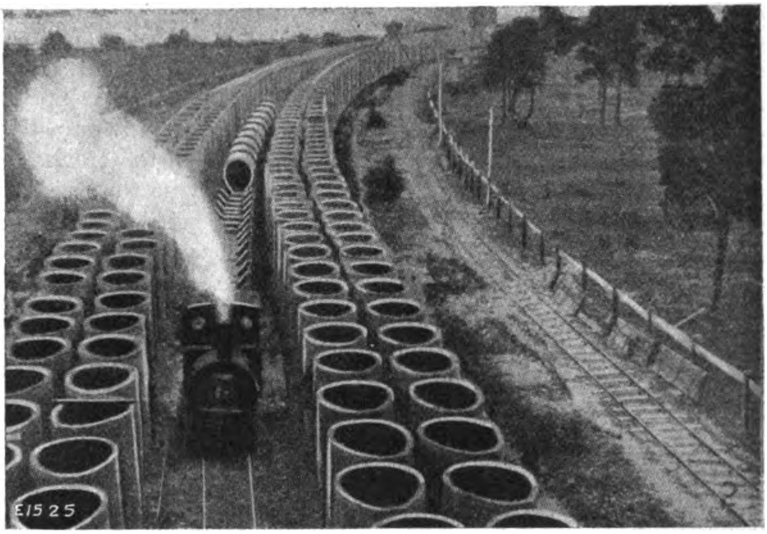
In fact, the following scheme was adopted :—After casting the pipes, within one hour the ends of the moulds were removed and left hanging on a traveller ; the top mould was then removed and also left hanging ; the truck was then wheeled out into the yard, allowing the concrete in the pipe to harden further. The pipe was then lifted by the internal mould and upended. Then the inner mould was removed in two sections. The inner mould was then re-erected and placed on the truck with the reinforcements round same. The truck was then taken under the traveller, the top moulds and ends put on, and the reinforcement adjusted by spacers in its exact position, and then brought under the receiver and filled. The tests of these pipes were severe. They were to be built to stand a load of 1,800 lb. per lineal ft., placed as a concentrated weight along a 4 in. rolled steel bar. An internal pressure of 30 ft. head of water was considered sufficient.



METHOD OF TESTING CONCRETE PIPES.

The laying of these pipes was interesting. Ten miles of 2 ft. 6 in. railway track gauge were laid for this work, and the handling was principally done by two steam locomotives, the pipes being carried upon specially shaped trucks. One difficulty raised against the use of long pipes was the suggested trouble of placing same in the tunnels, of which there were over two miles in the work. A truck was designed to get over this, and very little trouble was experienced.

The joints of the pipes were made under compressed air with a small portable petrol-driven compressor. The longitudinal reinforcement of the pipe projected at the ends and was incorporated into the joint reinforcement, so that a continuous pipe line was the result.



*From the "Commonwealth Engineer."*]

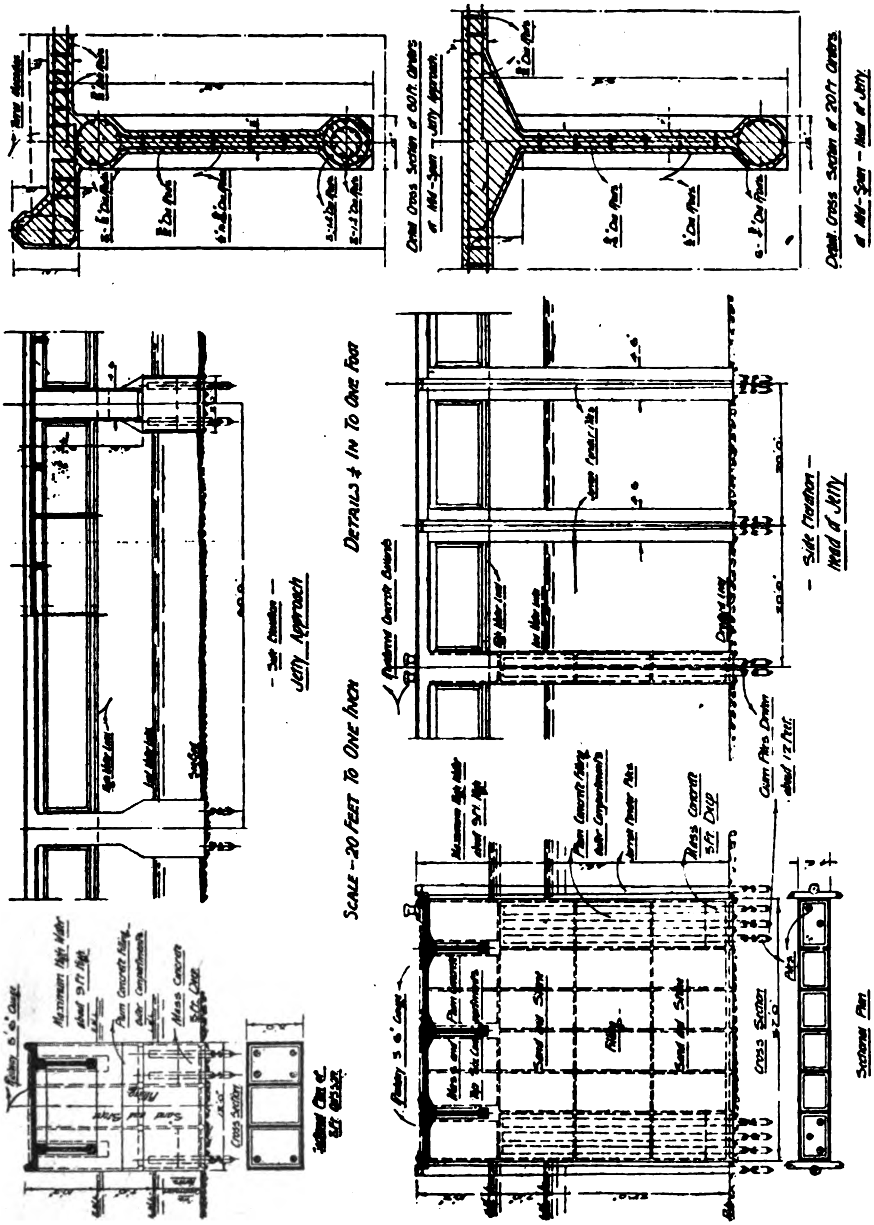
STORAGE YARD FOR CONCRETE PIPES, ALSO SHOWING LOCOMOTIVE TRACTOR.

### REINFORCED CONCRETE JETTY.

At the end of 1914 tenders were called by the South Australian Harbours Board for the design and construction of a jetty of about 1,200 ft. long at Cape Thevenard, on the west coast of South Australia, in the Great Australian Bight. Previous experience with the Sydney Harbour Trust led to the conclusion that jetties built of reinforced concrete piles were not suitable for heavy maritime conditions. A proper and separate fendering system is necessary where vessels of anything over 2,000 tons d.w. capacity berth against same, and even when the vessels are smaller the concrete piles must be of sufficient strength to take up the shock of berthing vessels. If this is not done, cracks occur below water line which are not seen, and in time the structure must become unsound and unstable. Hence it was suggested that caissons, spanned by deep girders, should be adopted for the piers.

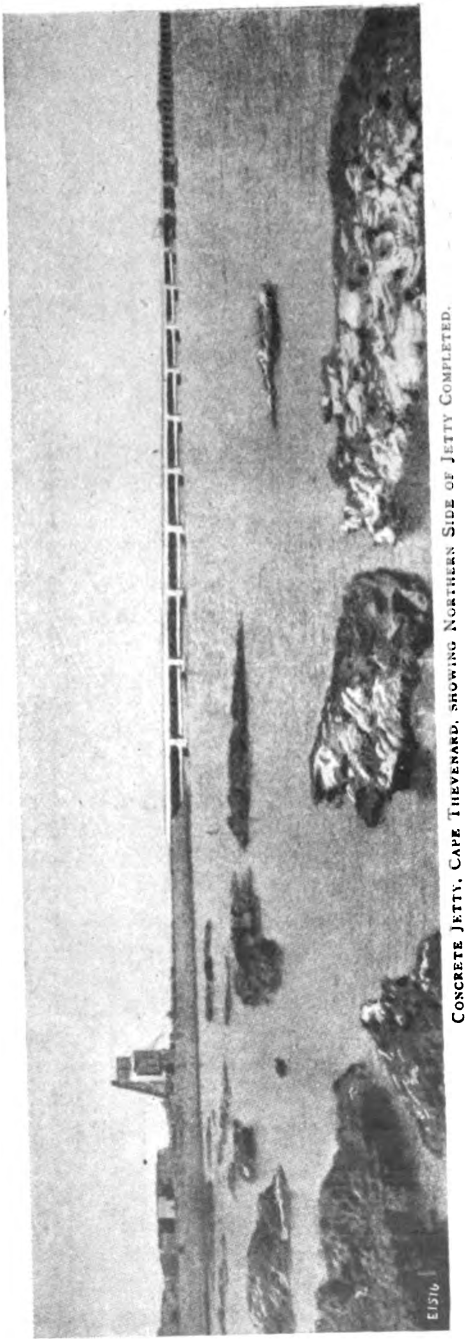
The design submitted was as follows:—For the approach: Eleven 60 ft. spans; caissons 18 ft. by 8 ft. by depth as required; width of deck between curb 16 ft. The girders adopted for the approach spans are 9 ft. 2 in. from top of deck slabs to underside of lower boom. For the jetty spans: Two 53 ft. spans and twenty 20 ft. spans; the caissons for the former are double and for the latter are single, and were cast on shore on launching ways. They are 37 ft. by 4 ft. 6 in. by 34 ft. high, and were cast on their flat with valves on the bottom end, through which water was allowed to enter. They then upended themselves into a vertical position and were drawn by steel ropes connected to winches into distance frames or spacers. Sufficient water was then allowed to enter to sink them vertically into their correct position.

The caissons were cellular, and into each of the two outer chambers three piles were driven and surrounded by poor concrete except for the lower three feet and the upper three feet, for which a 4 : 2½ : 1 mixture was used. The other chambers were filled with sand and stone to give weight and stability. The depth of water at the jetty spans is an even 27 ft. at L.W.O.S.T.; the range of tides at the jetty spans is a maximum of about 9 ft. under heavy winds. The caissons, after filling, were topped up to a height of about 43 ft. to underside of deck slab. There are three girders in the cross section of the jetty spans, which were cast on the

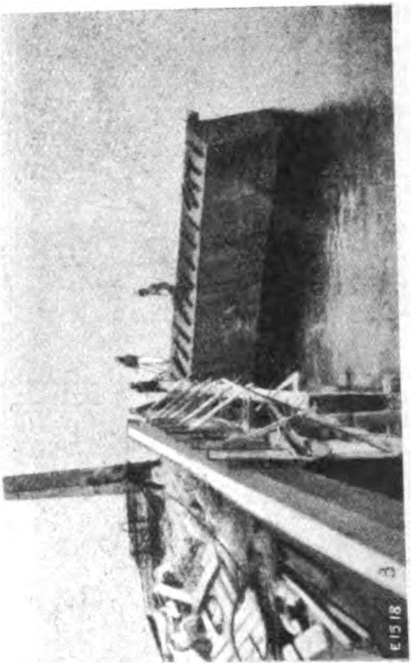

Detail Cross Section of 60 ft. Girders at Mid-Span Jetty Approach
Detail Cross Section of 20 ft Girders at Mid-Span – Head of Jetty
Side Elevation – Jetty Approach
Side Elevation – Head of Jetty
Details ¼ In To One Foot
Scale – 20 Feet To One Inch
Cross Section
Sectional Plan

Reinforced Concrete Jetty. Cape Thevenard—General design and details.

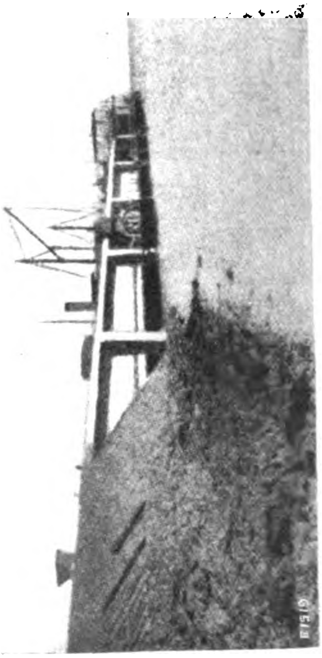
From the "Commonwealth Engineer."



Concrete Jetty, Cape Thevenard, showing Northern Side of Jetty Completed.



Caisson for Jetty Spans, after upending, being brought into position between distance frames



[From the "Commonwealth Engineer."]

Approach Portion of Cape Thevenard, Six Spans Concreted, the Seventh ready for Concreting.

deck of the approach spans ; the upper booms of girders were not cast on the shore, but the necessary reinforcement projects and forms a bond. The girders thus cast as units were brought up on a carriage under a jib crane at the head of the work and lowered into properly prepared seats. The top booms of girders and decking were then cast in one operation with kerbs and reinforced concrete double-headed bollards. The girders for the 20 ft. spans are of the same depth as for the approach spans. The idea of building such deep girders for the smaller spans was (1) to allow a solid bracing in lieu of building and casting troublesome small members, (2) to reduce the boom stresses, and (3) to preserve the same line of girders throughout the whole work. The structure is designed to carry a deck load of 5 cwt. per sq. ft., and a locomotive with a tender of 45 tons, or a wheel base extending over 30 ft. 6 in.

The jetty, now completed, is perhaps as fair an example of jetty construction as has been done, but, as is well understood, designs are not only to be considered from the point of view of the completed structure, but from the building aspect as well ; that is to say, commercial practicability has to be taken into account. Where heavy seas, with waves up to 6 ft. in height, occur, building upon caisson system needs special precautions. There is, of course, not much difficulty in providing sufficient strength to hold the caissons as far as spacers and distance frames are concerned, but the constant movement of the waves gradually breaks all fastenings, and should a storm occur just after a caisson is placed, losses must be allowed for, unless the caisson is designed to be stable in itself. Apart from this, the caisson design is sound in principle, and offers a good opportunity to engineers for meeting the many difficulties that present themselves in designs of marine structures.

The material available for the concrete of the Cape Thevenard jetty was not the best. The stone is of excellent quality for compressive strength, being granite procured on the foreshore, but this stone has not a good adhesion. The sand, however, seems to be a disintegrated limestone—too fine in the grain for the best marine work. But, strangely enough, the concrete in a continuous deck, over 1,000 ft. long, shows no signs of cracking, although no expansion joints have been allowed for.

Concerning the lasting qualities of concrete in salt water much can be written. Over 15 years' experience has convinced the author that, with suitable cement and proper regard to relation of density as compared with compressive strength, Portland cement concrete can be relied upon to last apparently an indefinite period. Concrete tested after 15 years' immersion in salt water shows an increase in compressive strength, and the reinforcement when properly protected no sign of deterioration.

# THE CONCRETE INSTITUTE.

## MONTHLY NOTES.

By the SECRETARY

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**ANNUAL DINNER OF THE CONCRETE INSTITUTE AT THE HOLBORN RESTAURANT ON THURSDAY, DECEMBER 9th, 1920 (OPEN TO MEMBERS AND GUESTS), TICKETS AT FIFTEEN SHILLINGS EACH (WINES, etc., NOT INCLUDED).**

Special attention of the Members of the Institute is called to the following notice:—

Owing to the great expected demand for tickets for the above function members are requested to intimate to the Secretary at once whether it is their intention to be present. Tickets will be allotted in order of the receipt of such intimation.

The following gentlemen have expressed their intention to be present:—

The Rev. S. A. Alexander, M.A., Canon of St. Paul's Cathedral.

G. Gilbert Scott, Esq., A.R.A., F.R.I.B.A., President of the Architectural Association.

C. Le Maistre, Esq., Assoc.M.Inst.C.E., Secretary of the British Engineering Standards Association.

Arthur Crow, Esq., F.R.I.B.A., President of the District Surveyors' Association.

George Springfield, Esq., F.J.I., President of the Institute of Journalists.

J. A. Brodie, Esq., M.Inst.C.E., President of the Institution of Civil Engineers.

Captain H. Riall Sankey, C.B., R.E. (ret.), M.Inst.C.E., President of the Institution of Mechanical Engineers.

Reginald Brown, Esq., M.B.E., M.Inst.C.E., M.I.Mech.E., etc., President of the Institution of Municipal Engineers.

N. Scorgie, Esq., M.Inst.C.E., Vice-President of the Institution of Municipal and County Engineers.

W. R. Davidge, Esq., A.R.I.B.A., F.S.I., Assoc.M.Inst.C.E., District Surveyor for Lewisham, Ministry of Health (Housing Commissioner for the London Area).

Major Wightman Douglas, Ministry of Health (Commissioner for Special Construction).

S. B. Russell, Esq., F.R.I.B.A., Ministry of Health (Chief Architect).

H. Greville Montgomery, Esq., Organiser of the Building Trades Exhibitions.

Sir Aston Webb, K.C.V.O., C.B., F.R.I.B.A., etc., President of the Royal Academy.

John W. Simpson, President of the Royal Institute of British Architects.

John Willmot, Esq., President of the Surveyors' Institution.

## THE LATE EDMUND PERCY WELLS, ESQ., J.P., C.E.

Only those of us who are early members of the Concrete Institute can recognise how much the Institute owes to the energy and enthusiasm of Mr. Edmund Percy Wells, now deceased. His serial number in the list of members was as low as 15. He was of English nationality, but his earliest professional years were spent in lighthouse construction in Australia. At one time he was in the Engineers' department of the London County Council. For the last twenty years or more he was in private practice as a consulting engineer. During this period he designed the reinforced concrete work for very many important structures and buildings.

He was a man of great courage and strong convictions. If he held an opinion he never hesitated to express it. This outspokenness lost him many friends, who in mourning his death will forget the pain of occasional very candid criticism.

Fortunately, as Mr. Wells and the present writer from the commencement of their acquaintance agreed to hold divergent views on subjects other than the necessity of rapid methods of calculation and good quality of materials and workmanship, there was never any ripple on the tranquil sea of friendship.

Mr. Wells often denounced theories of every kind, but nevertheless in subjects not related to engineering he clung tenaciously to many theories which would charm the orthodox by their contrast with accepted views.

The writer had the greatest respect for Mr. Wells' energy and enthusiasm. His candour and honesty of purpose were outstanding characteristics of his temperament, and this brief memoir would be very incomplete without a reference thereto. It is proposed to give a fuller memoir at a later date, together with some information as to his principal works.

E. FIANDER ETCHELLS,
*President*, Concrete Institute.

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**COMMITTEE MEETINGS FOR OCTOBER AND NOVEMBER, 1920.**

| | | |
|---|---|---|
| October | 7th | Reinforced Concrete Practice Standing Committee, at 4 p.m.<br>Science Standing Committee, at 5.30 p.m. |
| ,, | 14th | Finance and General Purposes Committee, at 5.30 p.m. |
| ,, | 21st | Literature Standing Committee, at 5.30 p.m. |
| ,, | 28th | Council Meeting, at 5.30 p.m. |
| November | 4th | Reinforced Concrete Practice Standing Committee, at 4 p.m.<br>Science Standing Committee, at 5.30 p.m. |
| ,, | 11th | Finance and General Purposes Committee, at 5.30 p.m. |
| ,, | 18th | Literature Standing Committee, at 5.30 p.m. |
| ,, | 25th | Council Meeting, at 5.30 p.m.<br>Ordinary General Meeting, at 7.30 p.m. PRESIDENTIAL ADDRESS by E. Fiander Etchells, A.M.Inst.C.E., etc. |

## MEMORANDUM.

**Reinforced Concrete at Modder East.**—In a paper read before the South African Institution of Engineers, Mr. Thomas Blandford described a reinforced concrete dam employed for shutting off an inrush of water at Modder East. This dam was constructed in the 3-19 rise at No. 1 shaft, for the purpose of controlling and closing off a feeder of water which yielded approximately one million gallons per day at a pressure of 500 lbs. per sq. in. This outburst was met in the dyke through which the rise was being driven, and was found to be coming from a vertical fissure striking north and south. As soon as it was found that any temporary measures for reducing the quantity of water were useless, work was immediately taken in hand to build a reinforced concrete dam. A good concrete, consisting of 1 part cement, 1 sand, and 2 broken stone (dyke material on site), was well rammed into the face to a thickness of approximately 4 ft. No hitches for support were cut in the rock, but a series of forty 1-in. steel pegs were driven to a depth of 6 to 9 in. into the rock in two rows around the perimeter of the drive, such pegs projecting a distance of about 1 ft. 6 in. into the mass concrete. In addition to this, two rows of ½-in. bar iron, one vertical and one horizontal, the bars being about 1 ft. apart, were embedded into the concrete during construction and tied up by means of wire to the above-mentioned pegs, thereby forming a double grille system of reinforcement. In this way a thoroughly strong wall was obtained.

The feeder of water was confined behind the concrete to as small a channel as possible with the aid of 21-gauge steel sheets, and released through two 6-in. pipes fitted with stop valves. By this means it was possible to place the concrete in position correctly without any interference from the water. Six 1½-in. cementation pipes were also built in the dam for the purpose of filling and solidifying the fissure and the subsequent testing of the ground in advance. The work of construction of the dam occupied two days, being commenced on August 14th, 1919, and completed on the 16th, after which it was allowed to set for three days. During this period the feeder was flowing freely from the 6-in. drain pipes. Injection was then started on the 19th, and continued until the 27th, when all the pipes in the dam had been solidly closed with cement, and also two of the release holes in the hanging wall. At this stage approximately half the original feeder was shut off, but owing to shortage of cement it was not deemed advisable to close it all off, as there was no cement on hand should anything unforeseen take place by totally closing off the water, taking into consideration the short period that had been allowed for the maturing of the concrete.

# TWO AMERICAN REPORTS* ON CONCRETE RESEARCH WORK.

In another portion of the current number we have commented on two reports which have reached us from the Lewis Institute, Chicago : (*a*) A report giving an account of some tests carried out to ascertain the effect of hydrated lime and other powdered admixtures in concrete ; (*b*) Two appendices dealing with the recommended practice for making compression tests of concrete and the effect of tannic acid on the strength of concrete.

In our September number we printed an article by Mr. Wynn, which also dealt with the use of hydrated lime for concrete road construction, and for the assistance of those interested in the matter, we give below the summary of results as arrived at by the Lewis Institute :—

## (*a*) EFFECT OF HYDRATED LIME AND OTHER POWDERED ADMIXTURES IN CONCRETE.

**By DUFF A. ABRAMS.**

### SUMMARY.

Studies of the effect of hydrated lime and other powdered admixtures in concrete have been under way in this laboratory during the past four years. About 20,000 tests have been made in six different investigations.

Compression tests of hand-mixed concrete were made on 6 by 12-in. cylinders in which hydrated lime was added in quantities up to 50 per cent. of the volume of the cement. In one series, tests were made with 17 other powdered admixtures. The mix varied from 1 : 9 to 1 : 2, with wide variations in consistency and size and grading of aggregate. The age at test varied from 3 days to 1½ years. Wear and bond tests were made in certain groups. Tests were also made with sand and slag cements.

The following are the principal conclusions :

1. In general the addition of powdered materials reduced the strength of concrete approximately in proportion to the quantity of admixture. Some exceptions are noted below.

2. In usual mixtures, each 1 per cent. of hydrated lime (in terms of the *volume* of cement) reduced the strength of concrete 0·5 per cent. ; 1 per cent. by *weight* of cement reduced the strength 1.2 per cent. The reduction in strength caused by *replacing* cement with an equal volume of hydrated lime was about 1¾ times that caused by adding hydrated lime.

3. High calcium and high magnesium limes produced the same effect.

4. The addition of 1 per cent. of the following powdered admixtures in terms of the volume of cement *reduced* the strength of 1 : 4 concrete at 28 days by the following percentages : Brick, 0.08 ; clay, 0.22 ; whiting, 0.24 ; sand, 0.37 ; natural cement, 0.38 ; limestone, 0.39 ; lava, 0.40 ; fluorspar, 0.43 ; kaolin, 0.47 ; kieselguhr, 0.48 ; tufa, 0.51 ; hydrated lime, 0.56 ; ironite, 0.60 ; yellow ochre, 0.68 ; mica, 1.10 ; pitch, 1.50 ; gypsum, 4.00. For the same conditions the addition of 1 per cent. of cement *increased* the strength of concrete about 1 per cent.

5. Pulverized slag up to 50 per cent. of volume of cement gave a slight increase in strength of concrete (about 0.12 on the basis used above).

6. Rich concrete mixes showed a greater loss in strength due to powdered admixtures than the leaner ones. Very lean mixes (1 : 9 to 1 : 6) and in those with aggregates graded too coarse for the quantity of cement used, the strength was little affected or was slightly increased by admixtures up to 50 per cent.

7. The wetter mixes showed a greater loss in strength than the dry, due to the addition of hydrated lime.

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* Read at the 23rd Annual Meeting of the American Society for Testing Materials.

8. The effect of admixtures was in general independent of the age of the concrete.

9. Sand and slag cements gave results comparable to those from powdered materials simply mixed in the concrete.

10. Hydrated lime and other powdered admixtures used in these tests slightly increased the workability of the leaner mixes (1 : 9 and 1 : 6) as measured by the slump test. Ordinary mixes (1 : 5 and 1 : 4) were little affected ; richer mixes (1 : 3 and 1 : 2) were made less plastic.

11. The wear of concrete was not sensibly increased by hydrated lime or other admixtures up to 20 per cent. of the volume of cement.

12. The bond resistance was affected in the same manner as the strength by the presence of hydrated lime.

13. Hydrated lime had little effect on the absorption of dry concrete, increased the evaporation of water from wet concrete and produced no beneficial effect on the strength of concrete stored in air.

14. The yield of concrete was little affected by hydrated lime or other admixtures ; for the usual concrete mixes, 20 per cent. admixture increased the yield about 2.5 per cent.

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## (*b*) EFFECT OF TANNIC ACID ON THE STRENGTH OF CONCRETE.

**By DUFF A. ABRAMS.**

SUMMARY.

It has long been recognised that impurities of an organic nature have the effect of reducing the strength of concrete or entirely destroying the hydraulic properties of the cement. While this fact has been pointed out by a number of writers, there is still a tendency among concrete engineers to disregard the effect of such impurities. A general investigation of this subject was inaugurated in 1915 by means of funds furnished by Committee C-9 on Concrete and Concrete Aggregates and has been continued during the past four years as a part of the investigations being carried out through the co-operation of Lewis Institute and the Portland Cement Association.

It was impossible to secure natural sands containing graduated percentages of organic impurities for a study of the *quantitative* effect of such impurities. Consequently we prepared aggregate samples in which known quantities of organic impurities were present, by applying tannic acid as a surface coating in quantities up to 0.40 per cent. by weight. Compression tests were made on 3 by 6-in. concrete cylinders. The mix varied from 1 : 5 to 1 : 2 ; the size of aggregate ranged from a fine sand to a ¾-in. graded aggregate. Tests were made on all mixtures and sizes of aggregate at ages of 7 days, 28 days, 3 months, 1 year, and 2 years. Specimens were stored in damp sand. This series included about 2,000 concrete tests.

Following are the principal conclusions from this investigation :

1. It is believed that the results of these tests are typical of the effect produced by organic impurities in concrete.

2. The strength of concrete was reduced for all percentages of tannic acid, for all mixes and ages covered by these tests. Less than 0.1 per cent. of tannic acid in terms of the weight of the aggregate may reduce the strength of the concrete to one-half its normal value.

3. Lean mixtures are more affected by tannic acid than the rich ones.

4. The mixtures from the finer aggregates are less affected by tannic acid than those from the coarser aggregates.

5. All of the effects mentioned above may be summed up by saying that the reduction in strength of concrete is a function of the *concentration* of tannic acid in the mixing water. An equation is given which represents this relation for the 28-day tests.

6. The results of these tests indicate that the wetter consistencies would be less affected by the presence of organic impurities than the drier ones.

7. The strength falls off rapidly for small percentages of tannic acid and less rapidly as higher percentages are reached.

8. The 7 and 28-day strengths are reduced to a greater extent by tannic acid than at ages of 1 and 2 years.

9. Some of the 1 : 5 mixes in which the higher percentages of tannic acid and the finer sands were used (2 to 3 per cent. solution) disintegrated before the time of test. The 1 : 7 mixes (3 to 5 per cent. solution) were destroyed in removing the moulds.

10. The tests confirm the results of many other investigations made in this Laboratory in showing the fundamental dependency of strength of concrete on the quantity of mixing water as expressed by the water-ratio.

11. The strength of concrete (stored in a damp place) both with and without tannic acid increased with age. The strength for a given condition was a logarithmic function of the age.

Care should be taken to eliminate surface loam from concrete sands. Loam can generally be removed by washing.

Attention is called to the "colorimetric" test with sodium hydroxide as a convenient method of testing for organic impurities in natural sands.

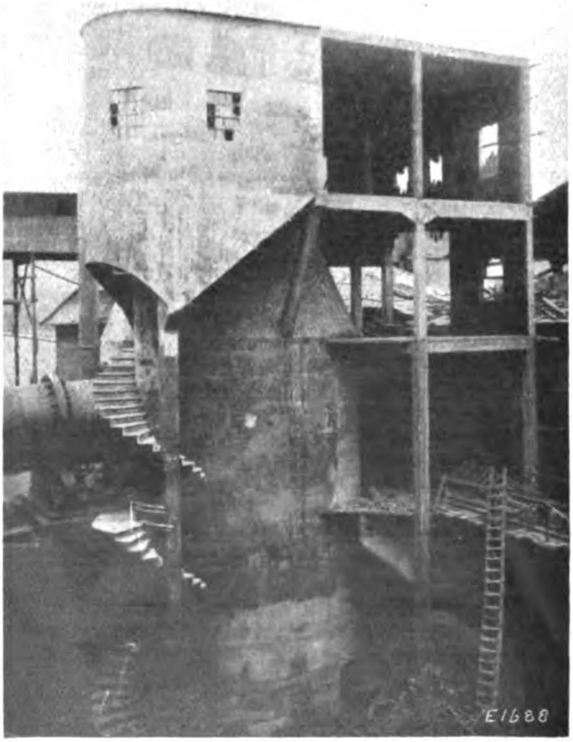

FIG. 6. A REINFORCED CONCRETE SMOKE CHAMBER FOR CHIMNEY AT SLEMMESTAD, NORWAY.

(*See page* 693)

# REINFORCED CONCRETE WORK ON THE CONTINENT.

WE illustrate on this and the following pages some examples of reinforced concrete work which have recently been carried out in Denmark, Norway and Finland, including a grain silo, a large warehouse, chimneys, and posts for electrical transmission lines.

The chimney illustrated in *Fig.* 1, erected at Norre Sundby, Denmark, is 170 feet high and 4 ft. 3 in. in diameter. This chimney tapers upwards, and is built in the shape of a shamrock at the base and circular at the top. A development of this type of chimney is illustrated in *Fig.* 4 of a chimney in course of erection in Finland. In this case the base is hexagonal in shape, with rounded corners, and as the chimney tapers towards the top the flat sides are gradually shortened until at the top course the chimney is circular. This result is obtained by an ingenious system of shuttering. At the base course the shuttering is built on the

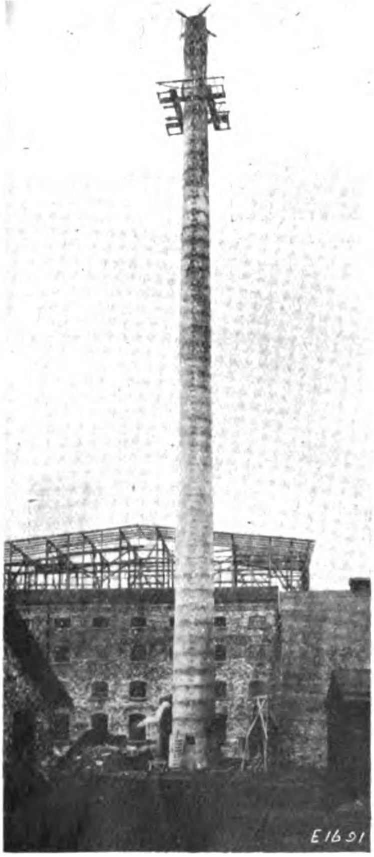

FIG. 1. REINFORCED CONCRETE CHIMNEY AT NORRE SUNDBY, DENMARK.

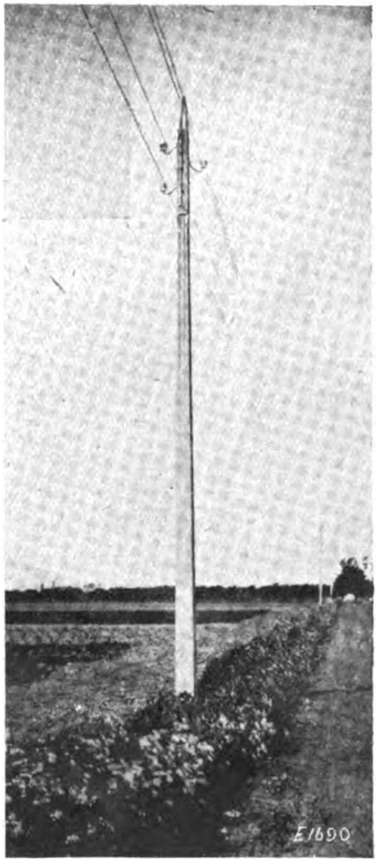

FIG. 2. REINFORCED CONCRETE MAST FOR CARRYING ELECTRIC TRANSMISSION LINES.

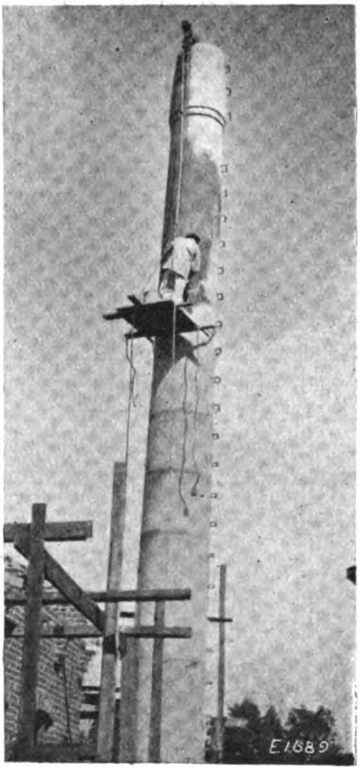

FIG. 3. A CHIMNEY IN COURSE OF CONSTRUCTION IN FINLAND.

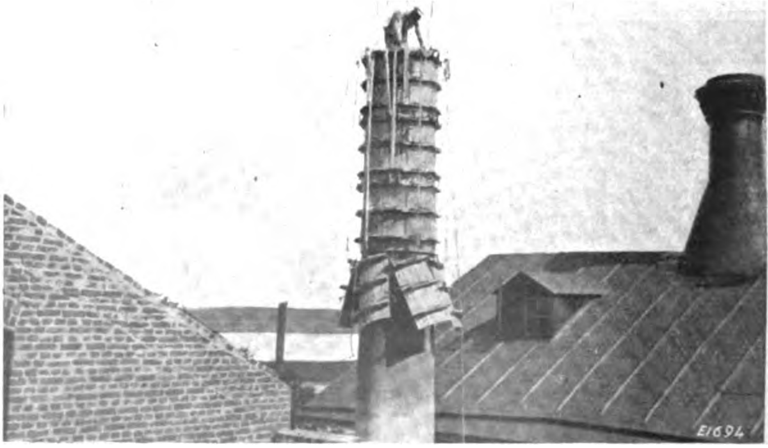

FIG. 4. SHOWING SYSTEM OF SHUTTERING EMPLOYED.

side of the chimney in the form shown in *Fig.* 5, in six sections, each section consisting of one rounded portion and half of each of the two adjacent straight portions. In order to form a tapered chimney, as each section in the height of the chimney is completed the straight portions of the shuttering are shortened until at the top course only the rounded portions remain, forming a complete circle. The shuttering is of timber and can be used over and over again. The interiors of the chimneys generally follow the outline of the exterior, but can of course, be made to any desired shape. In this type of construction the use of scaffolding is entirely eliminated, the work of construction being carried out from the inside. This is clearly shown in *Fig.* 4; as will be seen, the forms are hauled up as each section is completed and placed in position ready for the next course. This system of chimney construction (Moehl's patent) has been used in the construction of nearly 300 chimneys in Europe and Asia and several have been erected in this country; at Stone, near Dartford, for instance, there are six specimens, ranging in height from 75 ft. to 220 ft., and in diameter from 11 ft. to 2 ft. 6 in. *Fig.* 3 shows a reinforced concrete chimney built on the " Moehl " system in Finland, the cradle being used for finishing the exterior surface.

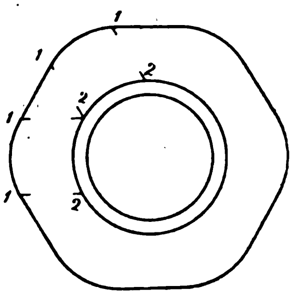

FIG. 5. PLAN OF "MOEHL" CONCRETE CHIMNEY.

A reinforced concrete smoke-chamber as a base for a chimney at Slemmestad, near Christiania, Norway, is illustrated in *Fig.* 6. The platforms and winding staircase shown are all in reinforced concrete.

A Danish example of a reinforced concrete post is shown in *Fig.* 2. In this case the standard, which is 27 ft. in height, is used for the purpose of carrying electric transmission lines. We understand that several thousands of these masts have been supplied for this purpose in and around Copenhagen and for many provincial towns in Denmark and Sweden. As will be seen from the photograph, the rigidity of the structure enables the guy ropes or other supports necessary for wooden posts to be dispensed with.

The other illustrations are of building construction. *Fig.* 7 shows a silo built for the storage of two different materials, one above the other. The contents of the lower compartments are discharged through the doors and the upper compartments through the spouts above. The total height to the conveyor house on top of the building is 78 ft.

The grain silo illustrated in *Fig.* 8 has been erected at Odense, Denmark. This silo has a capacity of 5,000 tons. The drying plant is situated in the basement, from whence the grain is carried on conveyors to the two towers; from these points it is distributed to any one of the 31 cells comprised in the silo. The offices and other apartments for the management are situated on the ground floor.

*Fig.* 9 is an interior view of a warehouse, with a floor area of 35,000 superficial feet, built for the storage of phosphate at Fredericia, Denmark. The L-shaped reinforced concrete members along the centre of the roof are for the support of rails along which an electrically-driven transporter will travel.

All the above-mentioned buildings, chimneys, etc., have been constructed by Messrs. Danalith, Ltd., reinforced concrete specialists, of Copenhagen, the London branch of which firm is Messrs. F. Moehl, Ltd., of 3 and 4, Lincoln's Inn Fields, London, W.C.2.

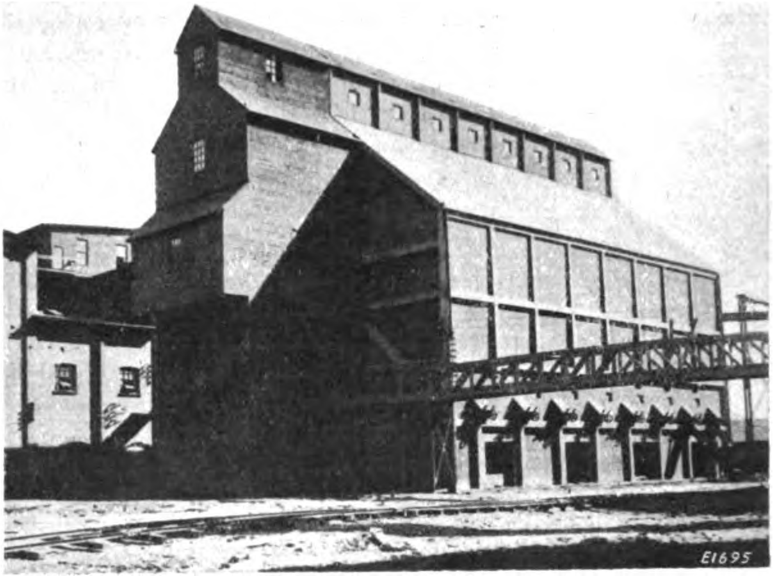

FIG. 7. A SILO FOR THE STORAGE OF TWO MATERIALS.

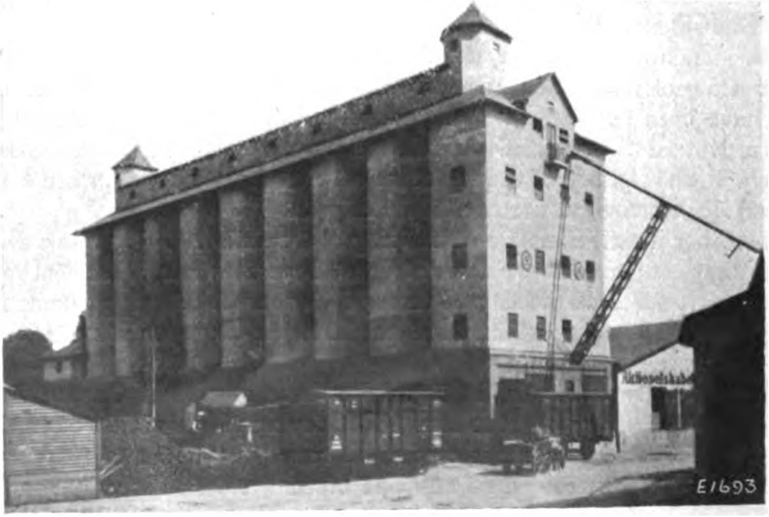

FIG. 8. GRAIN SILO AT ODENSE, DENMARK

A building carried out solely by Messrs. F. Moehl, Ltd., is illustrated in *Fig.* 10. These two cylindrical silos were constructed at Magheramorne, Ireland, for the

British Portland Cement Manufacturers, Ltd., to store 3,000 tons of cement each. The buildings are 60 ft. in height and 42 ft. in diameter, and while one is a single compartment the other is divided into two by a reinforced concrete division wall. The two chimneys in the background are of reinforced concrete constructed with "Moehl" forms.

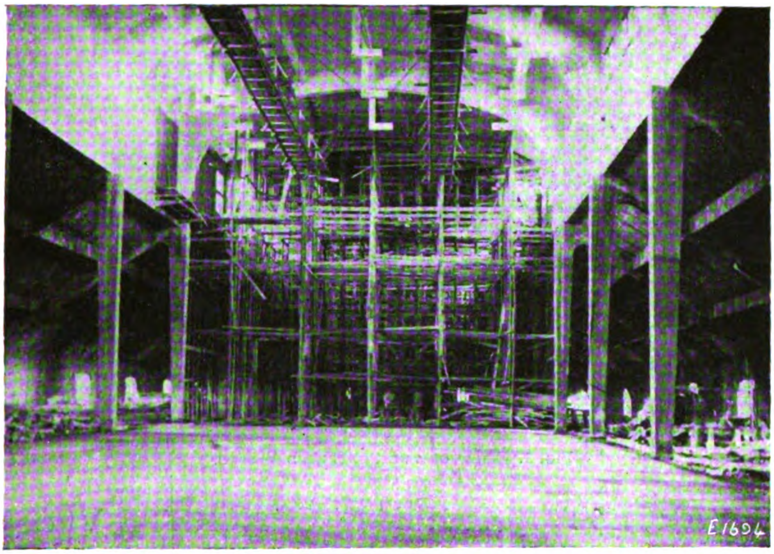

FIG. 9. INTERIOR OF A WAREHOUSE FOR THE STORAGE OF PHOSPHATES

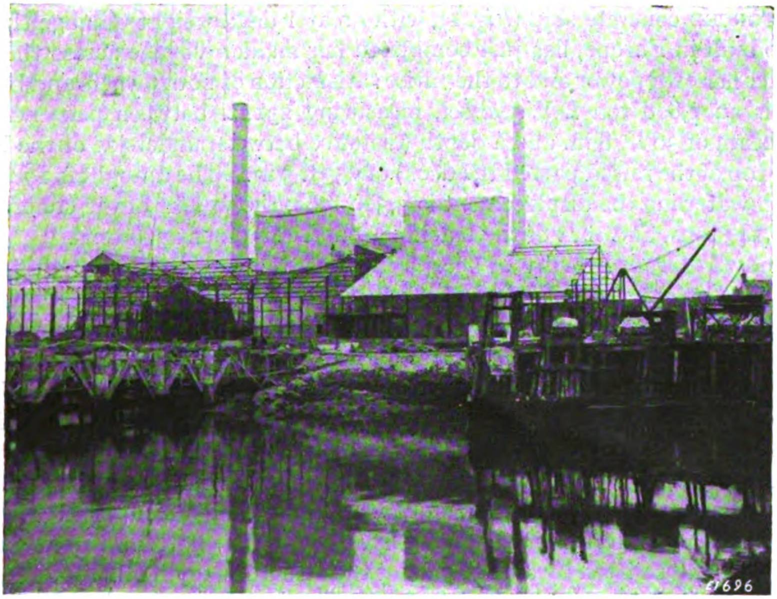

FIG. 10. SILOS AND CHIMNEYS AT MAGHERAMORNE, IRELAND.

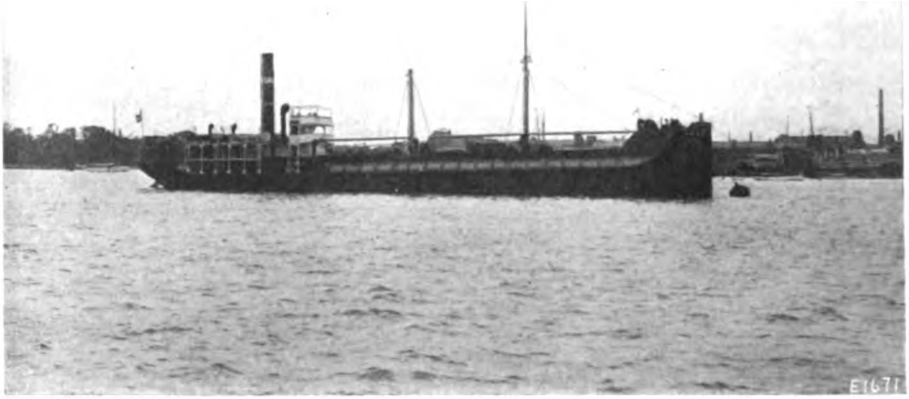

FIG. 1. VIEW OF THE COMPLETED VESSEL.

# THE LARGEST EUROPEAN CONCRETE VESSEL.

## By V. ELMONT, B.Sc.

A REINFORCED concrete ship (*Fig.* 1), with greater dead weight tonnage than any hitherto built in Europe, has just completed her maiden voyage across the North Sea under her own power and to the entire satisfaction of both owners and builders.

It is an 1,800 ton D.W. vessel, measuring 231 ft. between perpendiculars, with a beam of 36 ft. 8 in. and a depth (distance between underside of the bottom and the top of the raised part of the deck) of 25 ft. 5 in. The draught is 17 ft. 6 in., at which waterline the displacement is 3,300 tons, the weight of the concrete hull being 1,140 tons, and that of the machinery and equipment 360 tons.

A novel feature, worthy of special interest, in connection with this boat is her double bottom, the design of which is based on the patents and plans of the late Mr. K. Bartels, after whom the owners with a *beau geste* have named the vessel. The upper and lower slab of the bottom are connected by a number of longitudinal concrete trusses in inclined planes, two and two having top or bottom chord in common, as will be realised from *Fig.* 2 (midship section) and Frontispiece, which shows the reinforcing bars in place for part of the bottom and of the sides as well. By means of this design great strength and rigidity have been obtained by a relatively very small yardage of concrete and, therefore, appreciable weight reduction. Any external force acting locally on this bottom will directly be spread over and resisted by a large part of the structure, or, in other words, a blow would readily be absorbed by the large masses of concrete engaged.

The difficulty—and necessity—involved in placing the steel with the utmost exactness in accordance with the drawings has successfully been overcome by assembling each truss member in advance (some of the units can be seen in *Fig.* 3

before they were put in position) and afterwards joining them together. How effectively and strongly the many bars meeting at each panel point are interlocked is illustrated by *Fig.* 4, which shows a photograph of one of them. Further details of design are indicated in *Fig.* 6, where cross and longitudinal sections of the bottom are shown.

The frames supporting the sides of the vessel were also built up of pre-assembled bar units, to which was attached *in situ* the reinforcing steel for the wall slab. These latter bars are placed at an angle of 45 deg., sufficient sections being everywhere provided for the absorption of all the shear stresses.

The general outline of the deck is shown in *Fig.* 2, from which it will be noticed that the centre part is raised considerably, the purpose being to obtain a large arm for the internal forces which counteract the hogging and sagging moments, which again results in a saving in the steel and concrete areas necessary to resist these moments.

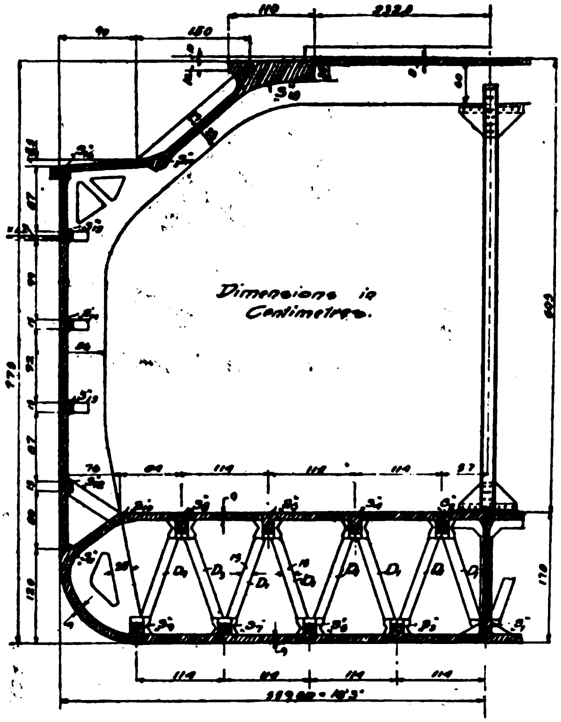

FIG. 2. MIDSHIP SECTION.

The bars provided against the hogging stresses are seen in *Fig.* 5; they are placed in the deck on either side of the hatchways and consist of 40 1½ in. bars (mild steel rounds) extending from stem to stern, the various parts of each bar being joined together by sleeve nuts. Towards the ends of the ship, the bars are securely anchored and spread out fanlike in the deck slab.

*Fig.* 7 shows the arrangement plans of the vessel. The engine and boiler rooms with appertaining bunkers are located astern. There is only one hold,

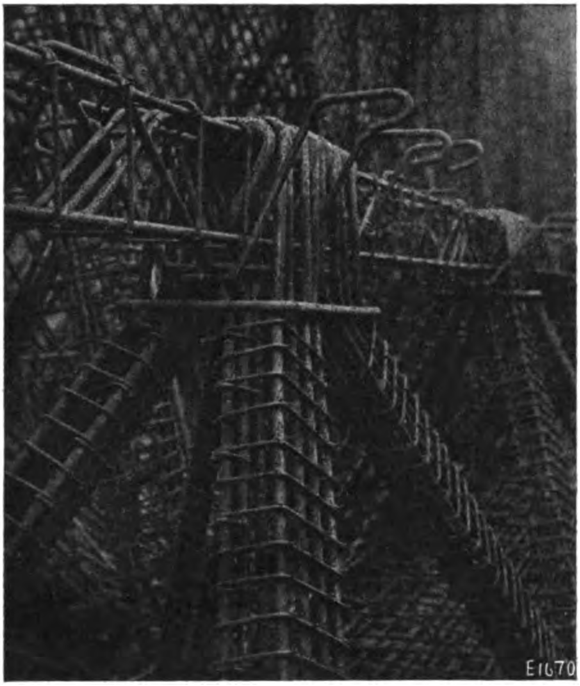

FIG. 4. DETAILS OF REINFORCEMENT.

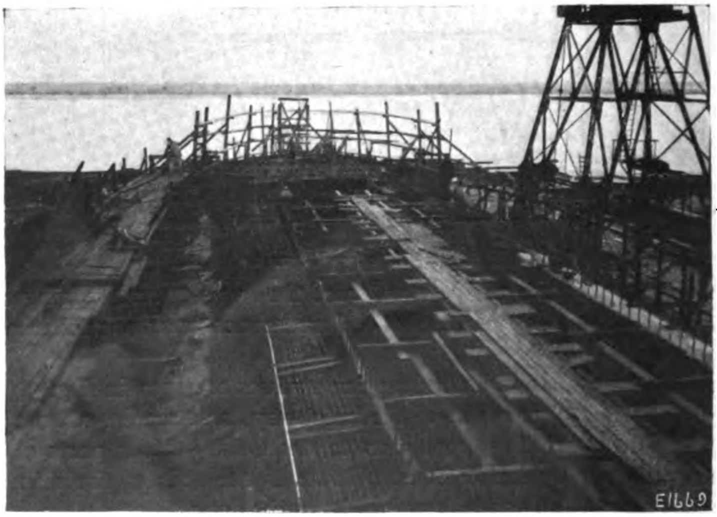

FIG. 5.

with a capacity of about 8,300 c. ft., to which lead three hatchways, measuring 26 ft. 4 in. by 15 ft. 3 in. Besides the usual collision bulkheads, a watertight bulkhead has been provided between the engine room and the hold.

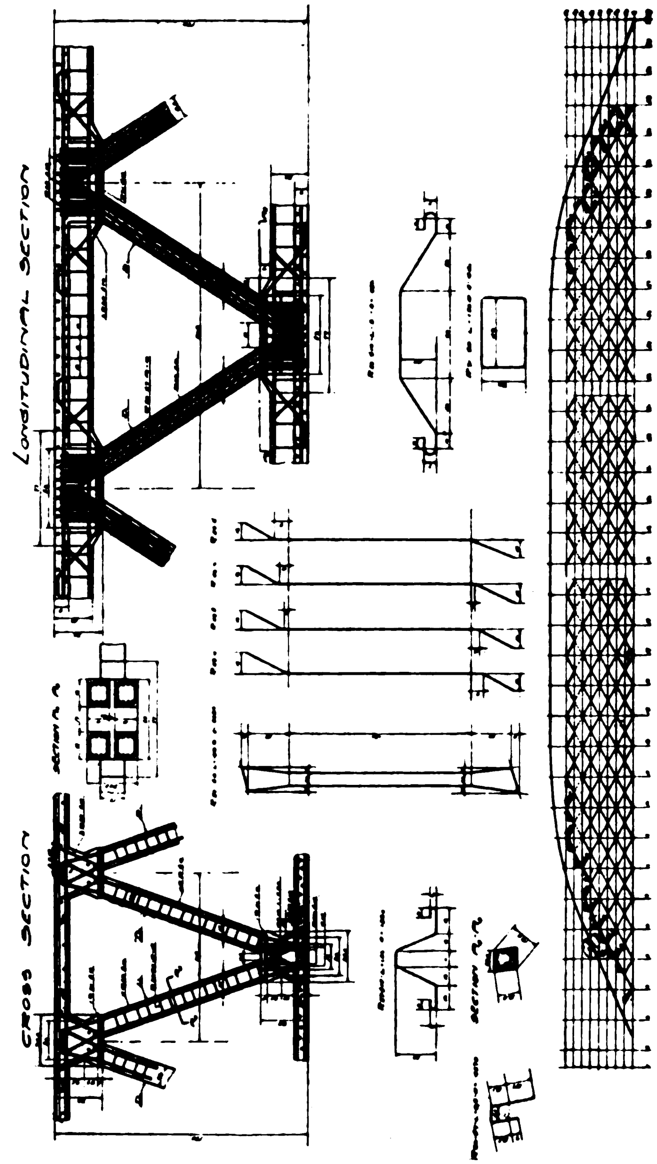

Fig. 6. Details of Design.

The vessel can carry in all 740 tons of water-ballast, distributed over the fore and aft peak and the double bottom, which for that purpose is divided into five separate tanks. Before the launching they were tested for 20 ft. water pressure and found to be absolutely tight.

The stem is protected by an oak fender fastened between two steel plates anchored to the concrete construction. The stern frame is of cast steel. The driving power necessary to reach the contract speed of 7½ knots is furnished by a 600 h.p. triple-expansion engine.

The design and construction of the concrete hull were in the hands of the Northern Trading and Engineering Co., Cyclone, under direction of its managing director, Mr. K. Hojgaard, while the equipment and machinery were supplied by the Copenhagen Floating Docks and Shipyards Co., in whose new dry dock the boat was built.

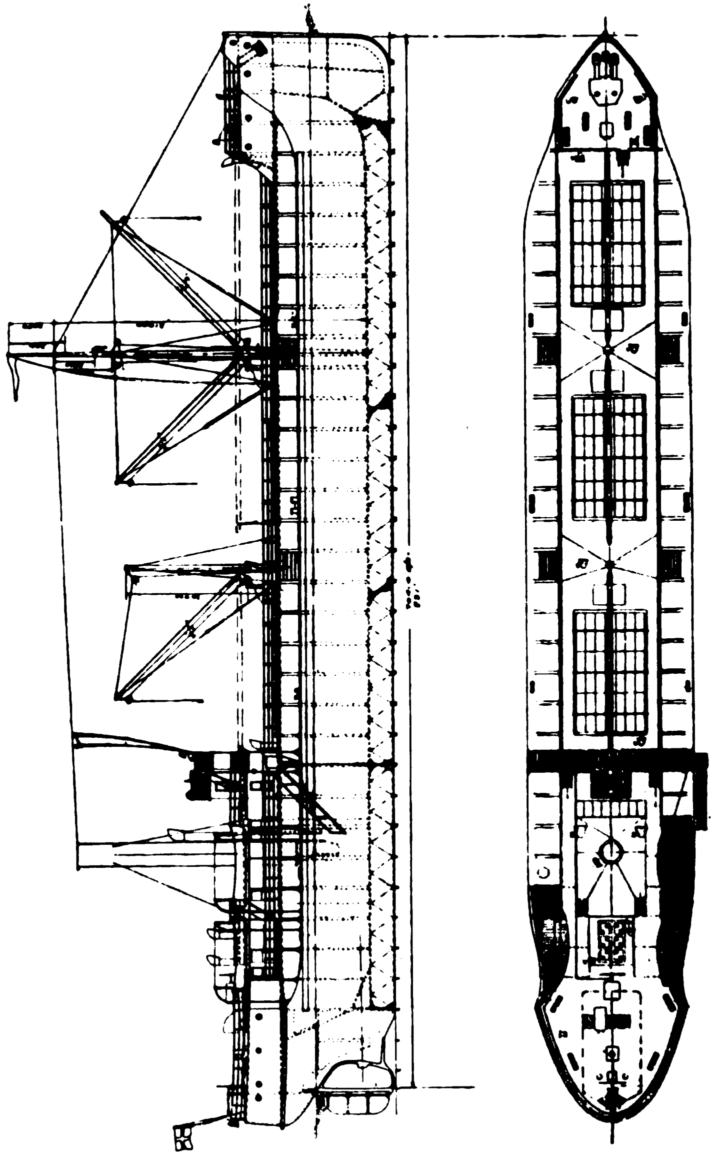

Fig. 7. Plans.

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER III.—*continued.*

51. As an example of beam design, let us take a continuous beam 25 ft. span, carrying a 6 in. slab, the load per sq. ft. being 200 lb. per sq. ft. inclusive, and the beams being 12 ft. apart.

The load per beam is :—

$$W = 25 \times 10 \times 200$$
$$= 50{,}000 \text{ lb.}$$

Taking the moment as $\frac{WL}{12}$, as suggested in par. 42, we have :—

Bending Moment :

$$M = \frac{50{,}000 \times 300}{12}$$
$$= 1{,}250{,}000 \text{ in. lb.}$$

300 being $L$, the span in inches.

Reference to our table in Article 50 shows that a beam $22 \times 8$ overall, reinforced with six 1-in. rods, gives a resistance moment of 1,330,000, in lb., a little more than required.

To see whether our slab is sufficient to carry the compression stresses, we note that the limiting width is :—

(*a*) distance between beams = 10 ft.
(*b*) one-third the span = 8 ft. 4 in.
(See Par. 48.)

Adopting the lesser of these, we have available a slab 8 ft. 4 in. × 6 in. thick.

From our table (Par. 50) we note our beam requires a slab 34·9 in. × 7·2 in. thick.

Though our slab is not quite the requisite thickness, this is more than compensated by its width being more than required.

52. It was shown, in Par. 42, that a continuous beam gives a bending moment of $+\frac{Wl}{12}$ at midspan, but also has a moment of $-\frac{Wl}{12}$ at the support.

Now the resistance moment given in the table in Par. 50 applies to the centre section of the beam, but does not apply to the support, because at the support the compression is at the bottom, and therefore the concrete slab, which so greatly assists at the centre section, is not available for compression.

The bending moment is $-1{,}250{,}000$ in. lb., as in the last paragraph.

If the end of the beam is calculated as a rectangular one, breadth 8 in., depth 20 in., its resistance would be about :—

$$R = 95 \times 8 \times 20^2 = 304{,}000 \text{ in. lb.}$$

It would really be somewhat greater, because the percentage of steel is greater than ·675 per cent., and there would be some steel on the compression side also, but there is no need here to go closely into this.

To make our beam strong enough at the support, it is therefore desirable to increase this moment of resistance approximately four times, which is done by doubling the depth at the end, since it will be remembered that the moment varies with the *square* of the depth.

Referring to the moment diagram at the bottom of *Fig.* 6 (p. 499), it will be seen that the reverse moment near the support dies away rapidly along the beam. The increased depth at the support may therefore die away gradually also, forming a haunch extending for one-eighth the span along the beam.

If the standard beams given in Article 50 are adopted, this general rule for designing the haunch may be adopted :—

*Overall depth of beam at support to be twice the overall depth at midspan.*

*Haunch to die away at a distance of* $\frac{L}{8}$ *along the span.*

This would therefore determine the shape of beam as in *Fig.* 8.

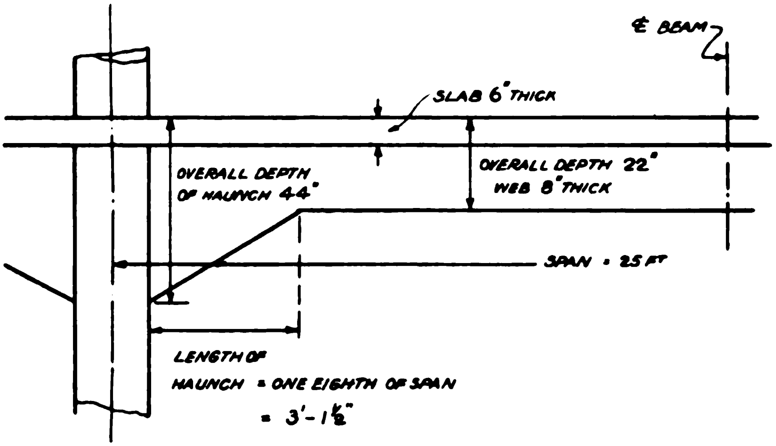
℄ BEAM
SLAB 6" THICK
OVERALL DEPTH OF HAUNCH 44"
OVERALL DEPTH 22" WEB 8" THICK
SPAN = 25 FT
LENGTH OF HAUNCH = ONE EIGHTH OF SPAN = 3'-1½"

FIG. 8

EXAMPLE OF CONTINUOUS BEAM

The depth and length of haunch should be measured at and from the edge of the column, as shown in the *Figure*.

The *arrangement* of the reinforcement cannot be determined until we have considered the question of shear.

## CHAPTER IV.

### *Shearing Resistance of Concrete Beams.*

53. If a beam is made strong to resist tension and compression at the bottom and top respectively, it may yet fail if the web connecting the tension rods to the compression area is too weak.

Resistance to this kind of failure is called *web resistance* or *shearing resistance*.

A full exposition was given in CONCRETE in Vol. XI., pp. 532 and 592, and in Vol. XII., pp. 419, 507 and 661, and the photographs of actual failures by shear should be studied. It will be seen that diagonal cracks extending from the tension face near the support up towards the load and the compression face are the chief characteristics of shear failure.

Obviously the best method of resisting shear is therefore to supply steel which will cut the weak tension planes and so prevent failure. This steel may consist of vertical hangers, or *stirrups*, or some of the tension rods may be bent up at about 45° to cross these planes, and are then called *bent up rods*. These constitute the two main forms of shear reinforcement.

(*To be continued.*)

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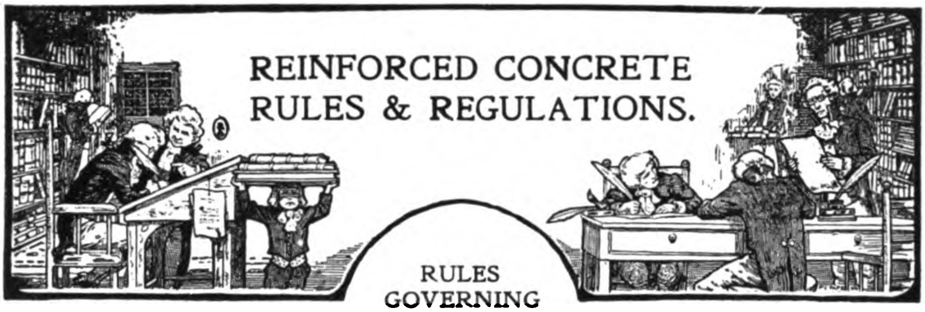
## MEMORANDUM.

**Sewage Purification Tank.**—In connection with the construction of sewage purification tank some novel methods of reinforced concrete were successfully applied. The work was carried out under the supervision of Messrs. Shenton and Easdale. For the purposes of purification it was necessary to construct channels spanning 25 ft., and this was done with the aid of concrete reinforced with triangle wire mesh and indented bars. They were cast on the ground, and when matured were lifted into position without any trouble. Above these channels it was necessary to construct a roof (at ground level) which could be easily removed when required. Reinforced concrete beams were cast and placed in position, and upon these pre-cast 2½ in. concrete slabs were placed.



# REINFORCED CONCRETE RULES & REGULATIONS.

## RULES GOVERNING THE DESIGN OF REINFORCED CONCRETE FLAT SLABS IN NEW YORK CITY

*Below we publish the Rules Governing the Design of Reinforced Concrete Flat Slabs in New York City, which came into effect on August 2nd of this year. Flat slab design is extensively used in America, although in this country it has not been widely adopted, and it is interesting to observe that New York City has now adopted special regulations for this type of reinforced concrete construction which hold good for all its boroughs. Up to the present the reinforced concrete regulations of the building code made no provision for it, and each borough had different ideas as to how this form of design should be treated.—ED.*

---

RULE 1. *Application.*—The rules governing the design of reinforced concrete flat slabs shall apply to such floors and roofs, consisting of three or more rows of slabs, without beams or girders, supported on columns, the construction being continuous over the columns and forming with them a monolithic structure.

RULE 2. *Compliance with Building Code.*—In the design of reinforced concrete flat slabs the provisions of Article 16 of the building code shall govern with respect to such matters as are specified therein.

RULE 3. *Assumptions.*—In calculations for the strength of reinforced concrete flat slabs, the following assumptions shall be made :—

(*a*) A plane section before bending remains plane after bending ;

(*b*) The modulus of elasticity of concrete in compression within the allowable working stresses is constant ;

(*c*) The adhesion between concrete and reinforcement is perfect ;

(*d*) The tensile strength of concrete is nil ;

(*e*) Initial stress in the reinforcement due to contraction or expansion in the concrete is negligible.

RULE 4. *Stresses.*—(*a*) The allowable unit shear in reinforced concrete flat slabs on $bd$ section around the perimeter of the column capital shall not exceed 120 lb. per sq. in. ; and the allowable unit shearing stress on the $bjd$ section around the perimeter of the drop shall not exceed 60 lb. per sq. in., provided that the reinforcement is so arranged or anchored that the stress may be fully developed for both positive and negative moments.

(*b*) The extreme fibre stress to be used in concrete in compression at the column head section shall not exceed 750 lb. per sq. in.

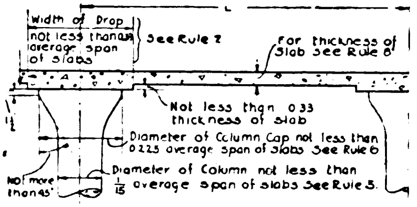
RULE 5. *Columns.*—For columns supporting reinforced concrete flat slabs the least dimension of any column shall be not less than 1/15th of the average span of any slabs supported by the columns ; but in no case shall such least dimension of any interior column supporting a floor or roof be less than 16 in. when round nor 14 in. when square ; nor shall the least dimension of any exterior column be less than 14 in.

RULE 6. *Column Capital.*—Every reinforced concrete column supporting a flat slab shall be provided with a capital whose diameter is not less than 0·225 of the average span of any slabs supported by it. Such diameter shall be measured where the vertical thickness of the capital is at least $1\frac{1}{2}$ in., and shall be the diameter of the inscribed circle in that horizontal plane. The slope of the capital considered effective below the point where its diameter is measured shall nowhere make an angle with the vertical of more than 45°. In case a cap of less dimensions than hereinafter described as a drop is placed above the column capital, the part of this cap enclosed within the lines of the column capital extended upward to the bottom of the slab or drop at the slope of 45° may be considered as part of the column capital in determining the diameter for design purposes.

RULE 7. *Drop.*—When a reinforced concrete flat slab is thicker in that portion adjacent to or surrounding the column, the thickened portion shall be known as a drop. The width of such drop when used shall be determined by the shearing stress in the slab around the perimeter of the drop, but in no case shall the width be less than 0·33 of the average span of any slabs of which it forms a part. In computing the thickness of drop required by the negative moment on the column head section, the width of the drop only shall be considered as effective in resisting the compressive stress, but in no case shall the thickness of such drops be less than 0·33 of the thickness of the slab. Where drops are used over interior columns corresponding drops shall be employed over exterior columns and shall extend to the sixth point of the panel from the centre of the column.

RULE 8. *Slab Thickness.*—The thickness of a reinforced concrete flat slab shall be not less than that derived by the formulæ $t=0\cdot024\,L\sqrt{w}+1\frac{1}{2}$ for slabs without drops, and $t=0\cdot02\,L\sqrt{w}+1$ for slabs with drops, in which $t$ is the thickness of the slab in in., $L$ is the average span of the slab in ft., and $w$ is the total live and dead load in lb. per sq. ft.; but in no case shall this thickness be less than 1/32nd of the average span of the slab for floors, nor less than 1/40th of the average span of the slab for roofs, nor less than 6 in. for floors, nor less than 5 in. for roofs.

PLATE 2


L
Width of Drop
not less than 0.33 average span of slabs
See Rule 7
For thickness of Slab see Rule 8
Not less than 0.33 thickness of slab
Diameter of Column Cap not less than 0.225 average span of slabs See Rule 6
Diameter of Column not less than 1/15 average span of slabs See Rule 5.
Not more than 45°
1½

RULE 9. *Reinforcement.*—(*a*) In the calculation of moments at any section, all the reinforcing bars which cross that section may be used, provided that such bars extend far enough on each side of such section to develop the full amount of the stress at that section. The effective area of the reinforcement at any moment section shall be the sectional area of the bars crossing such section multiplied by the sine of the angle of such bars with the plane of the section. The distribution of the reinforcement of the several bands shall be arranged to fully provide for the intermediate moments at any sections.

(*b*) Splices in bars may be made wherever convenient, but preferably at points of minimum stress. The length of any splice shall be not less than 80 bar diameters, and in no case less than 2 ft. The splicing of adjacent bars shall be avoided as far as possible. Slab bars which are lapped over the column, the sectional area of both being included in the calculation for negative moment, shall extend to the lines of inflection beyond the column centre.

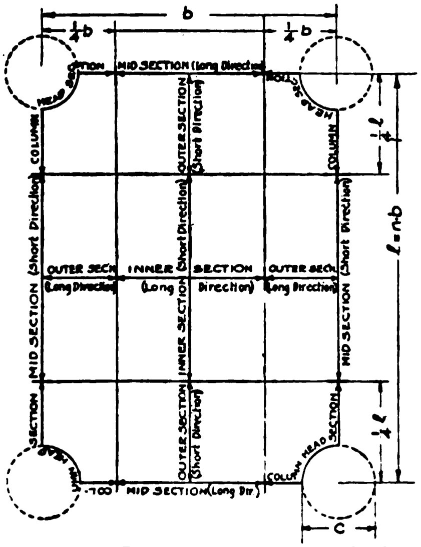
(*c*) When the reinforcement is arranged in bands at least 50 per cent. of the bars in any band shall be of a length not less than the distance centre to centre of columns measured rectangularly and diagonally; no bars used as positive reinforcement shall be of a length less than half the panel length plus 40 bar diameters for cross bands, or less than 7/10ths of the panel length plus 40 bar diameters for diagonal bands, and no bars used as negative reinforcement shall be of a length less than half the panel length. All reinforcement framing perpendicular to the wall in exterior panels shall extend to the outer edge of the panel and shall be hooked or otherwise anchored.

(*d*) Adequate means shall be provided for properly maintaining all slab reinforcement in the position assumed by the computations.

RULE 10. *Line of Inflection.*—In the design of reinforced concrete flat slab construction, for the purpose of making calculations of the bending moments at sections other than defined in these rules, the line of inflection shall be considered as being located one-quarter the distance, centre to centre, of columns, rectangularly and diagonally, from centre of columns for panels without drops, and 3/10ths of such distance for panels with drops.

RULE 11. *Moment Sections.*—For the purpose of design of reinforced concrete flat slabs, that portion of the section across a panel, along a line midway between columns, which lies within the middle two quarters of the width of the panel shall be known as the inner section, and those portions of the section in the two outer quarters of the width of the panel shall be known as the outer sections. Of the section which follows a panel edge from column to column and which includes the quarter perimeters of the edges of the column capitals, that portion within the middle two quarters of the panel width shall be known as the mid section and the two remaining portions, each having a projected width equal to one-quarter of the panel width, shall be known as the column head sections.

PLATE I


b
¼b
¼b
MID SECTION (Long Direction)
COLUMN HEAD SECTION
OUTER SECTION (Short Direction)
INNER SECTION (Short Direction)
MID SECTION (Short Direction)
OUTER SECTION (Long Direction)
INNER SECTION (Long Direction)
¼ℓ
ℓ=nb
·100
c

MOMENT SECTIONS FOR REINFORCED CONCRETE FLAT SLAB CONSTRUCTION

RULE 12. *Bending Moments.*—In the design of reinforced concrete flat slabs the following provisions with respect to bending moments shall be observed. In the moment expressions used :

$W$ is the total dead and live load on the panel under consideration, including the weight of drop whether a square, rectangle or parallelogram ;

$W_1$ is the total live load on the panel under consideration ;

$L$ is the length of side of a square panel centre to centre of columns, or the average span of a rectangular panel which is the mean length of the two sides.

$n$ is the ratio of the greater to the less dimension of the panel ;

$h$ is the unsupported length of a column in inches, measured from top of slab to base of capital ;

$I$ is the moment of inertia of the reinforced concrete column section.

*A. Interior Square Panels.*—The numerical sum of the positive and negative moments shall be not less than $1/17\,WL$. A variation of plus or minus 5 per cent. shall be permitted in the expression for the moment on any section, but in no case shall the sum of the negative moments be less than 66 per cent. of the total moment, nor the sum of the positive moments be less than 34 per cent. of the total moment for slabs with drops ; nor shall the sum of the negative moments be less than 60 per cent. of the total moment, nor the sum of the positive moments be less than 40 per cent. of the total moment for slabs without drops.

1. In *two-way systems*, for slabs with drops, the negative moment resisted on two column head sections shall be $-1/32\,WL$ ; the negative moment on the mid section shall be $-1/133\,WL$ ; the positive moment on the two outer sections shall be $+1/80\,WL$ and the positive moment on the inner section shall be $+1/133\,WL$ and for slabs without drops, the negative moment resisted on two column head sections shall be $-1/36\,WL$, the negative moment on the mid section shall be $-1/133\,WL$, the positive moment on the two outer sections shall be $+1/63\,WL$ and the positive moment on the inner section shall be $+1/133\,WL$.

2. In *four-way systems*, the negative moments shall be as specified for two-way systems ; the positive moment on the two outer sections shall be $+1/100\,WL$, and the positive moment on the inner section shall be $+1/100\,WL$ for slabs with drops ; and the positive moment on the two outer sections shall be $+1/74\,WL$, and the positive moment on the inner section shall be $+1/100\,WL$, for slabs without drops.

3. In *three-way systems*, the negative moment on the column head and mid sections and the positive moment on the two outer sections, shall be as specified

for four-way systems. In the expression for the bending moments on the various sections the length $L$ shall be assumed as the distance centre to centre of columns, and the load $W$ as the load on the parallelogram panel.

*B. Interior Rectangular Panels.*

1. When the ratio $n$ does not exceed 1·1, all computations shall be based on a square panel of a length equal to the average span, and the reinforcement shall be equally distributed in the short and long directions according to the bending moment co-efficients specified for interior square panels.

2. When the ratio $n$ lies between 1·1 and 1·33, the bending moment co-efficients specified for interior square panels shall be applied in the following manner:

(*a*) In *two-way systems*, the negative moments on the two column head sections and the mid section and the positive moment on the two outer sections and the inner section at right angles to the long direction shall be determined as for a square panel of a length equal to the greater dimension of the rectangular panel; and the corresponding moments on the sections at right angles to the short direction shall be determined as for a square panel of a length equal to the lesser dimension of the rectangular panel. In no case shall the amount of reinforcement in the short direction be less than 2/3 of that in the long direction. The load $W$ shall be taken as the load on the rectangular panel under consideration.

(*b*) In *four-way systems*, for the rectangular bands, the negative moment on the column head sections and the positive moment on the outer sections shall be determined in the same manner as indicated for *two-way systems*.

For the diagonal bands, the negative moments on the column head and mid sections and the positive moment on the inner section shall be determined as for a square panel of a length equal to the average span of the rectangle. The load $W$ shall be taken as the load on the rectangular panel under consideration.

(*c*) In *three-way systems*, the negative and positive moments on the bands runnig parallel to the long direction shall be determined as for a square whose side is equal to the greater dimension; and the moments on the bands running parallel to the short direction shall be determined as for a square whose side is equal to the lesser dimension. The load $W$ shall be taken as the load on the parallelogram panel under consideration.

*C. Exterior Panels.*—The negative moments at the first interior row of columns and the positive moments at the centre of the exterior panels on moment sections parallel to the wall, shall be increased

TABLE I.

COMPARISON OF MOMENT FACTORS,

REINFORCED CONCRETE FLAT SLAB DESIGN

W = Total Load on Panel = $wL^2$ L = Length of Square Panel

Dimension of Capital Assumed as 0.225L; of Drop, as 0.33L.

| AUTHORITY | MOMENT SECTIONS | | | | TOTAL MOMENT | REMARKS |
|---|---|---|---|---|---|---|
| | 2-COL HEAD | MID | INNER | 2 OUTER | | |
| NEW YORK CITY Rules Adopted 7-8- | $-\frac{1}{32}WL$ | $-\frac{1}{133}WL$ | $+\frac{1}{133}WL$ | $+\frac{1}{80}WL$ | $\frac{1}{17}WL$ | |
| CHICAGO<br>CINCINNATI<br>INDIANAPOLIS<br>MINNEAPOLIS | $-\frac{1}{30}WL$<br>$\dagger -\frac{1}{34}$ | $-\frac{1}{120}WL$<br>$\dagger -\frac{1}{135}$ | $+\frac{1}{120}WL$<br>$\dagger +\frac{1}{135}$ | $+\frac{1}{60}WL$<br>$\dagger +\frac{1}{68}$ | $\frac{1}{15}WL$<br>$\dagger \frac{1}{169}$ | Allow Steel Stress of 18,000 lbs sq in factors marked † are based on Steel stress of 16000 lbs sq |
| PHILADELPHIA<br>BALTIMORE | $-\frac{1}{32}WL$ | $-\frac{1}{128}WL$ | $+\frac{1}{128}WL$ | $+\frac{1}{80}WL$ | $\frac{1}{169}WL$ | |
| PITTSBURGH | $-\frac{1}{296}WL$ | NOT SPECIFIED | $+\frac{1}{128}WL$ | $+\frac{1}{64}WL$ | $\frac{1}{154}WL$ | $\frac{WL}{16}$ = Total Positive Moment on Circular Section thru Panel Ctr |
| DETROIT | $-\frac{1}{51}WL$ | $-\frac{1}{116}WL$ | $+\frac{1}{118}WL$ | $+\frac{1}{62}WL$ | $\frac{1}{15.3}WL$ | |
| ST LOUIS | $-\frac{1}{33}WL$ | $-\frac{1}{133}WL$ | $+\frac{1}{133}WL$ | $+\frac{1}{67}WL$ | $\frac{1}{16.6}WL$ | |
| NEW YORK CITY BOR OF MANH (Superceded Rules) | $-\frac{1}{24}WL$ | $-\frac{1}{140}WL$ | $+\frac{1}{140}WL$ | $+\frac{1}{48}WL$ | $\frac{1}{13}WL$ | |
| TAYLOR & THOMPSON | $-\frac{1}{277}WL$ | $-\frac{1}{157}WL$ | $+\frac{1}{104}WL$ | $+\frac{1}{693}WL$ | $\frac{1}{15.1}WL$ | |
| MENSCH | $-\frac{1}{306}WL$ | $-\frac{1}{768}WL$ | $+\frac{1}{128}WL$ | $+\frac{1}{512}WL$ | $\frac{1}{137}WL$ | |
| S M I | $-\frac{1}{36}WL$ | $-\frac{1}{172}WL$ | $+\frac{1}{104}WL$ | $+\frac{1}{92}WL$ | $\frac{1}{185}WL$ | |
| NICHOLS | | | | | $\frac{1}{112}WL$ | Distribution not Specified |
| JOINT COMMITTEE<br>WASHINGTON<br>BOSTON | $*-\frac{1}{26}WL$<br>$-\frac{1}{32}WL$ | $-\frac{1}{104}WL$ | $+\frac{1}{138}WL$ | $+\frac{1}{58}WL$<br>$+\frac{1}{[illegible]}WL$<br>$+\frac{1}{495}WL$ | $\frac{1}{13}WL$ | Pos Moment = 37½ % Total<br>Neg Moment 62½ % Total<br>Minimum Specified Values Given for Each Section |
| AM CONCRETE INST | $*-\frac{1}{308}WL$<br>$-\frac{1}{385}WL$ | $-\frac{1}{154}WL$ | $+\frac{1}{128}WL$ | $+\frac{1}{855}WL$ | $\frac{1}{154}WL$ | Pos. Mom = 33⅓ % Total<br>Neg Mom = 66⅔ % Total<br>Min Spec Values for Each Sec |
| FORMULAE Derived Analytically | $*-\frac{1}{26}WL$<br>$-\frac{1}{32}WL$ | $-\frac{1}{178}WL$ | $+\frac{1}{118}WL$ | $*+\frac{1}{72.3}WL$<br>$+\frac{1}{87}WL$ | $\frac{1}{151}WL$ | Pos Mom = 35 % Total<br>Neg Mom = 65 % Total<br>Min Spec Values for Each Sec |

* With and Without Drops. NOTE: Third Value of Joint Committee Moment on Outer Section Used to Determine Slab Thickness Only

In the preparation of the rules the data obtained from the many extensometer tests made both on actual structures and at recognised experimental laboratories on test structures, was carefully analysed and considered. It has been stated that the fundamental principles of applied mechanics determine the design of flat slabs as they do of all other structures. Yet designing engineers and mathematicians differ radically in the application of those fundamental principles to this type of structure because there exist factors which have not yet been satisfactorily analysed and reduced to a basis of practical design.

20 per cent. over those specified above for interior panels. The negative moment on moment sections at the wall and parallel thereto shall be determined by the conditions of restraint, but the negative moment on the mid section shall never be considered less than 50 per cent. and the negative moment on the column head section never less than 80 per cent. of the corresponding moments at the first interior row of columns.

*D. Interior Columns* shall be designed for the bending moments developed by unequally loaded panels, eccentric loading or uneven spacing of columns. The bending moment resulting from unequally loaded panels shall be considered as 1/40 $W_1 L$, and shall be resisted by the columns immediately above and below the floor line under consideration in direct proportion to the values of their ratios of $I/h$.

*E. Wall Columns* shall be designed to resist bending in the same manner as interior columns, except that $W$ shall be substituted for $W_1$ in the formula for the moment. The moment so computed may be reduced by the counter moment of the weight of thestructure which projects beyond the centre line of the wall columns.

*F. Roof Columns* shall be designed to resist the total moment resulting from unequally loaded panels, as expressed by the formulæ in paragraphs (*D*) and (*E*) of this rule.

RULE 13. *Walls and Openings.*—In the design and construction of reinforced concrete flat slabs, additional slab thickness, girders or beams shall be provided to carry any walls or concentrated loads in addition to the specified uniform live and dead loads. Such girders or beams shall be assumed to carry 20 per cent. of the total live and dead panel load in addition to the wall load. Beams shall also be provided in case openings in the floor reduce the working strength of the slab below the prescribed carrying capacity.

RULE 14. *Special Panels.*—For structures having a width of less than three rows of slabs, or in which exterior drops, capitals or columns are omitted, or in which irregular or special panels are used, and for which the rules relating to the design of reinforced flat slabs do not directly apply, the computations in the analysis of the design of such panels shall, when so required, be filed with the superintendent of buildings.

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## MEMORANDUM.

**Grab Dredging Plant in the Fen District.**—In a recent issue of *Engineering* particulars and illustrations were given of a grab dredger which has been constructed for the South Level Commission, Ely, and put to work on the River Ouse. The plant possesses a number of interesting features, the vessel itself, designed and constructed by Mr. E. G. Crocker, consulting engineer to the Commission, being of reinforced concrete.

The vessel consists of three reinforced concrete pontoons having an overall length of 72 ft., an overall beam of 22 ft. and a draught, when fully loaded, of 3 ft. 9 in. The side pontoons are of 5-ft. beam, connected to the central pontoon by four 9-in. by 4-in. rolled steel joists, fitted with the necessary bearing plates and secured by 1½ in. bolts, and are readily detachable so as to allow of the passage of the vessel through locks, the central pontoon then carrying the complete plant on a draught of 4 ft. The vessel is fitted with a double-cylinder steam winch, having six drums forward and with the necessary bollards and fairleads to enable the vessel to be manœuvred by the means of the anchors and wire rope cables without hand labour. A cabin has been fitted out to provide living accommodation for the crew of two men, and movable shelters are provided over both the crane and boiler to protect the workmen from the weather. The reinforced concrete pontoons were constructed in 1916, and have been afloat since early in 1917. The decision to build the vessel in reinforced concrete was made mainly on the question of cost, the quotation for 50-ft. steel pontoons being £1,500, whereas the actual cost of the concrete pontoons was £839 9s. 9d., including the increase in the price of the connecting girders, bollards, etc. from 1916 to 1919, amounting to £65. The concrete is composed of 1 part of Portland cement, 1½ part of sand and 2½ parts of broken granite measured by volume, these proportions giving a concrete which for a thickness of 2 in. is impervious under the conditions to which the vessel is subject, the pontoons being absolutely dry inside provided the mixing and depositing are carried out in a proper manner.

The dredging equipment comprises a steam grab designed and manufactured by Priestman Brothers, Ltd., of Holderness Foundry, Hull.

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

*In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.--ED.*

*Question.—L. D. writes :—*

1. *What objection is there to designing the majority of floor beams on the assumption of free ends, as the greatest strength is usually at the centre due to tee beam action, always allowing that some of the tension bars would be carried up as shear members, and taken well over the supports, whether column or otherwise? The reasoning is that if the centre of the span is designed on the assumption of freely supported ends, the centre deflection is so small that the slope at the ends of the beam is almost nil, and therefore the negative tension is small, and the bent-up bars would distribute any small hair cracks which appear, and it is obvious that if there were no bars and the beam over the support developed a vertical crack from the top the beam would still be perfectly safe. Of course the beam would have stirrups for shear and small steep (say, 45°) haunches as brackets. This idea is apparently borne out by L.C.C. reg. 91. The reason for raising this is that with so many beams the L.C.C. demand* $\frac{WL}{10}$ *at the centre and supports, and the compression flange at the supports is so narrow in comparison with the centre of the tee that either a great amount of compression steel is required or a very deep haunch, which is unsightly and interrupts headroom, also very little extra depth is required at the centre of the tee beam to take* $\frac{WL}{8}$ *instead of* $\frac{WL}{10}$ *or even* $\frac{WL}{12}$.

*This scheme would also relieve any moment on the columns.*

2. *Are you of the opinion that the L.C.C. by taking 15 diameters height (which seems low, considering that the Americans use 18), and the apparently excessive ·005 minimum lateral reinforcement and maximum pitch of ·6 diams. at centre and ·3 diams. at ends, intend to make allowance for + or − bending due to beams on columns?*

*Answer.*—1. The objections to designing continuous floor beams on the assumption of free ends and bending up a few bars over the support all depend on what moments are designed for and what proportion of bars are bent up. It is clear that if the centre of the span is designed for $\frac{WL}{8}$ and half the steel is bent up over the support from each side, there would be the same steel over the top of the support as at mid-span; and as the moment of the support would never reach $\frac{WL}{8}$, these rods would never be over-stressed, and, therefore, tension cracks over the support would not occur. The concrete at the bottom of the beam near the support might be over-stressed, but probably in the great majority of cases the over-stressing would not be very serious when the moment of inertia at mid-span, being so much greater than that at the end, was adequately allowed for and taken into account, together with the fact that although the centre was designed for $\frac{WL}{8}$ the moment there would actually be something less. This means lower stresses near mid-span and consequently less deflection. The chief objection is that with material locally over-stressed to an unknown extent, as would certainly be the case at the bottom of the beam near the support in many instances, it is impossible to ascertain with any certainty what the real factor of safety is, and it is clear that failure would take place by the concrete at the bottom of the beam near the support crushing, after which the beam would be liable to fail in shear at this point.

2. We believe it is the intention of the L.C.C. that bending moments due to beams shall be allowed for on columns, and one of the regulations specifying that the stresses shall be the combined stresses of all the forces distinctly implies this, though at present there is considerable ambiguity as to how these moments should be calculated, and the L.C.C. have not specified this. Our own view is that these moments should be properly allowed for, and that in nearly all practical cases where this has been done reduction of stress owing to the length of column and the limitation of the height of column to 15 diameters is quite unnecessary.

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# NEW BOOKS

## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

### How to Estimate. By John T. Rea.

London: B. T. Batsford, 94 High Holborn. 544 pp. + xvi.

*Contents.*—Introductory—The Cost of Buildings—Labour—Preliminary and Provisions — Excavator — Concretor — Drainlayer — Bricklayer — Mason — Pavior — Slater — Tiler — Thatcher—Carpenter, Joiner and Ironmonger—Smith and Ironfounder — Coppersmith — Bellhanger — Plumber — Zincworker — Plasterer — Painter — Glazier — Paperhanger —Gasfitter—Miscellaneous Memoranda.

This volume is a reprint of the Fourth Edition, published in January, 1913, a few minor corrections only having been made, and a thorough revision of the prices has been deferred until the building trade has emerged from its present unsettled condition. Very few will care to prophesy when prices will become settled again, and at the present time it is almost impossible to obtain a definite estimate from a builder for the purpose of entering into a lump sum contract on account of the uncertainty in the prices of material and labour. This volume, however, is intended to serve as a treatise upon the principles of estimating apart from the question of actual rates, because even in normal times a variation will be found in the rates which prevail in various localities. Owing to lack of training in the proper method of estimating many contractors in the past were compelled to work by rule of thumb methods, and consequently suffered financial loss when the execution of the work called for special appliances and materials. This condition is inexcusable to-day, when a complete treatise on the principles of estimating, such as the one under review, is available, and where reliable data is kept of actual costs the contractor should be in a position to give an accurate estimate for any scheme, subject to variation only in case of fluctuations in the price of materials and labour after the estimate is prepared. This volume should form a part of every estimator's library, as it will prove a valuable guide when working up prices for any section of building work. A. L.

### Arrol's Bridge and Structural Engineer's Handbook. Adam Hunter.

E. & F. N. Spon, Ltd., 57 Haymarket, S.W.1. 21/- net

This work gives in great detail shearing forces, bending moments, and deflections of beams under different loadings and fixings, bending moments on columns under wind stresses and bracket loads, strength of columns, strength of foundations and piles, stresses in roof trusses, wind pressure, properties of geometric sections, etc.

We anticipated finding in this work much information about bridges and kindred structures which would be new and a result of the great experience of the author. In this we were disappointed, and much of the contents is easily recognisable from the usual text-books and pocket-books, although the moment diagrams in columns due to wind and brackets are better presented than is usual.

Only a single page is devoted to the Forth Bridge, while 28 pages (208–235) are devoted to the area, modulus, etc., of geometrical sections, and could easily have been compressed into a quarter of this space without loss of clearness.

The information about brickwork and concrete appears to be considerably out of date; for example, the crushing strength of 4 to 1 cement mortar (standard sand) is given on p. 153 as 31·5 tons per sq. ft. (=490 lb. per sq. in.) in four weeks, though it is quite common now to get over 2,000 lb. per sq. in.

Reinforced concrete finds no place in the book, nor could we find tables of standard joists, angles, etc., or any of their properties, which we should have thought would find a place in a structural engineer's handbook.

### Retaining Walls: Their Design and Construction. By George Paaswell, C.E.

London: McGraw-Hill Publishing Co., Ltd., 6 and 8 Bouverie Street, E.C.4. Price 24/- net.

*Contents.* — Earth Pressures — Gravity Walls — Reinforced-Concrete Walls —Miscellaneous Wall Sections— Temperature and Shrinkage—Plant —Form Work—Concrete Construction—Walls other than Concrete— Architectural Treatment—Drainage —Waterproofing—Field and Office

Work — Specifications — Bibliography.

Were it not for the fact that the author of this book treats his subject in a somewhat different manner to the numerous other authors who have published text-books on this branch of engineering construction, we should have suggested that enough had already been written on the subject. In *this* country at least a dozen books have been written on "Retaining Walls," and in America probably a larger number. The chief defect in the book is that some of the illustrations are not well reproduced, and most of them are too small for the engineering student to thoroughly appreciate. The first chapter (which includes 41 pages) deals with the "Theory of Earth Pressure," and might have been dealt with in half that space, while the diagrams like those shown on pages 11 and 27 are too confusing for the engineering student to follow. The chapter on "Reinforced-Concrete Retaining Walls" is one of the best, but the illustrations of the typical examples of walls (as shown on page 79) are to too small a scale for the arrangement of the reinforcement to be clearly shown. One chapter cannot deal with this method of construction.

Some of the illustrations of retaining walls represent American examples; the dry-rubble wall shown in *Fig. A*, plate I., page 47, represents a wall which is very unstable, and such a structure would never be built in England; neither would that shown in *Fig. B*, plate I., page 47, or *Fig.* 37, page 75. The specifications and bibliography given on pages 254–269 are very useful, as is Chapter VIII. on "Concrete Construction." The chapter on "Plant" might well be enlarged, about one half of the text in Chapter I. being eliminated to make room for it, and what remains being made a little more elementary.

The book generally is to be recommended, but many of the methods of construction described follow the American practice, and would not be adopted in this country. The book is well printed, and some of the illustrations (*Fig.* 133, page 247, for example) are excellent. One of the principal recommendations of the book is that it gives us an opportunity of studying and comparing American *versus* British methods of construction.

**Waterproofing Engineering. By Joseph Ross, B.S., C.E.**

London: Chapman & Hall, 11 Henrietta Street, W.C.2
442 pp.+x. Price 25/- net.

*Contents.*—Need and Function of Waterproofing—Systems of Waterproofing—Impervious Roofing—Waterproofing Expansion Joints in Masonry—Waterproofing Materials—Waterproofing Implements and Machinery—Technical and Practical Tests of Waterproofing — Waterproofing Specifications—Practical Recipes and Special Formulæ — Waterproofing Applied—Cost Data on Materials, Implements and Labour, etc.

Despite the great importance of the subject, waterproofing is seldom treated in a thorough manner by writers on technical aspects of construction work, and, in consequence, there is very little literature available to the engineer who is faced by a problem unlike any he has previously met with, and in connection with which some guidance is required. This condition makes the appearance of the volume very welcome, as it constitutes a complete treatise, and it is written by an author who has had considerable practical experience in the subject, apart from the experimental research work upon which he has been engaged in connection with the preparation of this book. There are a large number of waterproofing materials on the market, but a secrecy is maintained as to their constituents. Mr. Ross has dispelled much of this secrecy by the aid of chemistry, and has thus done a great service to engineers generally. When it is realised that the value of practically every structure depends on its capacity to keep out moisture, the importance of the subject will be appreciated. The author speaks of the present era as the "Concrete Age," and devotes considerable space to the methods to be adopted to ensure satisfactory watertight work with this material. A very good chapter is that dealing with expansion joints in masonry—the latter term being applied by American writers to concrete and brick as well as stone—and some useful illustrations of joints used in important structures are given. The section describing technical and practical tests on waterproofing is also very instructive, and many interesting results are shown.

The book can be thoroughly recommended, as it is the best one which we have seen on this particular subject. A. L.

# CORRESPONDENCE.

*Under this heading we invite correspondence.*

## COKE-BREEZE CONCRETE.

*To the Editor of* CONCRETE AND CONSTRUCTIONAL ENGINEERING.

DEAR SIR,—As a manufacturer, and also a pioneer of this industry in my own district, and a subscriber to your journal, I should be glad if you would kindly permit me to make a few remarks in reference to an article which appeared in the August issue of your journal in reference to "coke-breeze" concrete.

I might mention first of all that during my practical experience in the manufacture of partition blocks for the last eleven years I have never used "coke-breeze," and whilst I do not agree with a good many of the conditions laid down in the "Specification for Cement Concrete Building Approved by Standardisation and Construction Committee of the Ministry of Health," I must admit that I certainly do agree with their contention that "coke-breeze" *must not* be used.

It was not until recently that I actually came across partition slabs made entirely of "coke-breeze," and then they were only being manufactured in small quantities.

"Coke-breeze," to my idea, is *not* fire-resisting; it stands to reason that it cannot be, as it is used, as everyone knows, for domestic and commercial purposes as fuel. Whilst admitting that it possesses advantages, amongst them being its porosity, and also that it affords the possibility of driving nails into it, I consider from a fire-resisting point of view that it is a dangerous article to use.

A few weeks ago I had an opportunity of examining some blocks made entirely from "coke-breeze," and I passed the remark to the maker that I thought it was not fire-resisting, and he admitted to me that some little time ago he used these blocks in constructing a portion of a fireplace, with the result that it nearly set the house on fire, the consequence being that the blocks had to be taken out and some other material substituted.

As far as partition blocks are concerned, I think that the word "coke-breeze" should be absolutely deleted, and the word "clinker-concrete" substituted.

I feel confident that if the large manufacturers of these blocks were asked what material they used they would, in ninety-nine cases out of a hundred, say "clinker or ashes"; and apart from any other point, it must be borne in mind that "coke-breeze" is very expensive, and from a practical point of view for the manufacture of blocks in large quantities, I am afraid that it would not pay.

There has been, to my idea, a lot of unnecessary restriction placed on "clinker" as a material for the manufacture of these blocks. Whilst admitting it is advisable to have the clinker, as far as practical, free from coal dust, I fail to see the disadvantages of a small piece of coal in a cement block, and if all manufacturers had to wash their "clinker," and were bound to mix a proportion of sand in not less than 5 per cent. or not more than 10 per cent., they may as well close down their works. I have seen thousands of yards of clinker blocks made, and I have not yet come across any that have had sand mixed with them; also, I have supplied thousands of yards of "clinker" blocks for Government contracts, and have never had any complaints whatsoever, and I am sure that there are a good many firms who also have supplied thousands of yards of these blocks and have not received any complaints as to their consistence, and I certainly think that the Government have been ill-advised in regard to the manufacture of these blocks.

Were there any blocks made of "coke-breeze" on the Concrete Utilities Bureau Stand at the Royal Agricultural Show, Darlington? I do not remember seeing any. I should say they were all made of clinker ashes, with perhaps a proportion of "smoke-box ashes."

Turning to another article in the August issue, "The Bognor Hutting Scheme," I quote the following: "The aggregate was clinker from the refuse destructor and the proportion 6 to 1. . . ." "The hut itself was surplus war material, and the aggregate of the concrete, refuse destructor clinker, was before the war looked upon as an encumbrance which local authorities found difficulty in disposing of."

It would be rather interesting to know if Mr. Bridges "washed all his refuse destructor clinker" before using the same, and also if he has secured a Government subsidy on his "Hutting Scheme"; if so, this should once and for all settle a point which is now worrying a good many manufacturers, builders and speculators.

In reference to "refuse destructor clinker," personally I do not find it a good aggregate, as there is always a certain amount of old tin cans, glass, and a thousand-and-one things that have been collected with the refuse.

I have repeatedly heard it stated that blocks made with "clinker ashes" will expand. In the manufacture of blocks from "clinker" it must be borne in mind that the blocks are seasoned and dried before being used in building construction; therefore the blocks should have shrunk or expanded before being used. I myself have fixed thousands of yards of blocks, and also inspected thousands of yards, and I have never yet come across a wall that has expanded after being built with properly seasoned blocks, unless some chalk or lime has got into the material when in manufacture.

I consider that there is a vast difference between the laying of a large floor in situ than in the manufacture of single blocks. I have known cases where big situ floors expanded; this has been usually accounted for, either by the cement expanding, or some foreign matter has got mixed with the concrete.

I have also heard it remarked that the specification laid down by the Ministry of Health is given only as a guide, and that if a local surveyor approves of the block and grants a certificate, the Ministry of Health are willing to accept his approval and grant a subsidy. This, to my mind, leaves a good deal of discretion to the local surveyor; what one surveyor may pass another one will not, and this kind of discretion is, to my idea, opening up a rather large subject. It seems to me most unfair that in one district a man may build a house and get his Government subsidy, and in another district a house may be built of the same material and *no* Government subsidy: this has actually happened in my experience.

Now, if the Government wish to see the housing question finished, this is certainly not the way to proceed. Why cannot the Ministry of Health meet a fully representative deputation of bona fide manufacturers of concrete blocks, and settle once and for all what is really required? I feel sure that the manufacturers themselves would be only too pleased to co-operate with the Ministry of Health and help them in any way possible, and by doing so it would save a tremendous lot of time, and would, I feel sure, also be a solution to the great problem before us, viz.:—"The Housing Question."

I am, Dear Sir,
Yours faithfully,
CHAS. J. MANNELL,
Concrete Manufacturer and Patentee.

Petra Place, Poole Hill,
Bournemouth W.
September 2nd, 1920.

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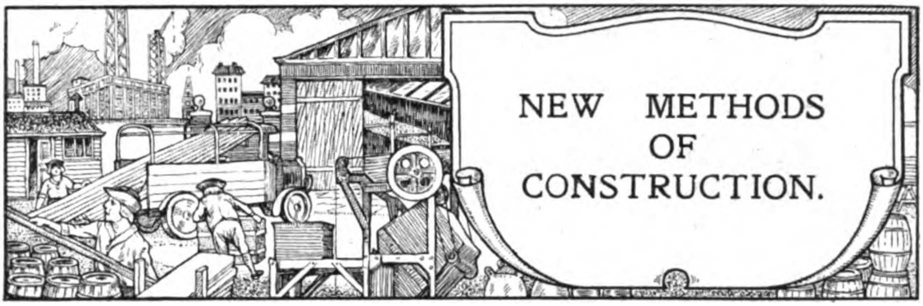
*Coke-breeze blocks were exhibited on the stand of the Concrete Utilities Bureau at the Royal Agricultural Show at Darlington* —ED.


NEW METHODS OF CONSTRUCTION.

*In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—ED.*

## THE "JEFFERIES" PATENT SYSTEM OF CONCRETE BLOCK CONSTRUCTION.

THIS system of construction, which has been officially approved by the Ministry of Health, consists of a hollow concrete wall built of patent blocks.

The blocks are made in one operation, including a finished face, and we are informed they can be produced at the rate of 40 blocks per hour per man. The method of "frogging" used is said to give a saving in material of 30 per cent., as compared with the ordinary solid concrete blocks.

A double wall is erected with a continuous cavity to ensure perfect dryness and even temperature to the interior of the building.

The outer blocks are 2 ft. 3 in. by 9 in. by 3 in., manufactured with a waterproof face, and the inner blocks are 2 ft. 3 in. by 9 in. by 4 in. and finished with a porous face. There is a 2 in. cavity between the outer and inner blocks, which are tied together by means of metal wall ties, two to the super yard.

The patent floor blocks are composed of two slabs, the floor slab and the ceiling slab, which are manufactured in such a manner as to form a concealed chamber.

These slabs are placed into position as soon as the beams are lodged in their proper centres and built in.

This is a very economical and rapid method of flooring, there being no trimming for hearths or staircase-ways, and the blocks are finished complete in the machine precisely in the same manner as the wall blocks.

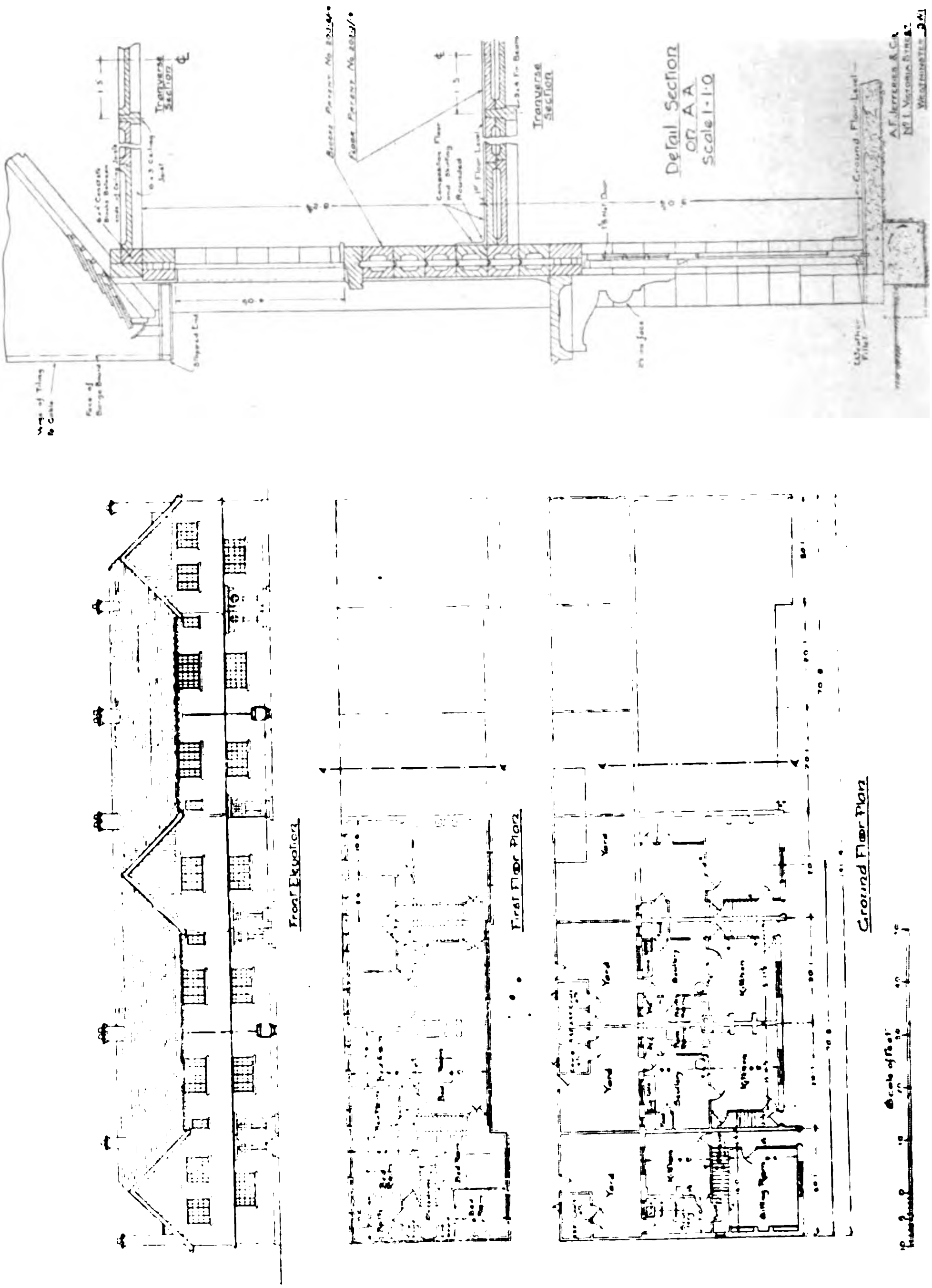
The slabs are made in various lengths to enable any width floor being spanned, viz. :—2 ft. 6 in., 2 ft. 8 in., and 2 ft. 10 in. by 1 ft. 6 in. wide.

The illustration on page 714 shows some details of the method of construction, as well as elevations and plans for some miners' cottages in course of erection for Messrs Lambton and Hetton Collieries, Limited. Full details can be obtained from Messrs. A. F. Jefferies & Co., Building Contractors, 1, Victoria Street, Westminster, S.W.1

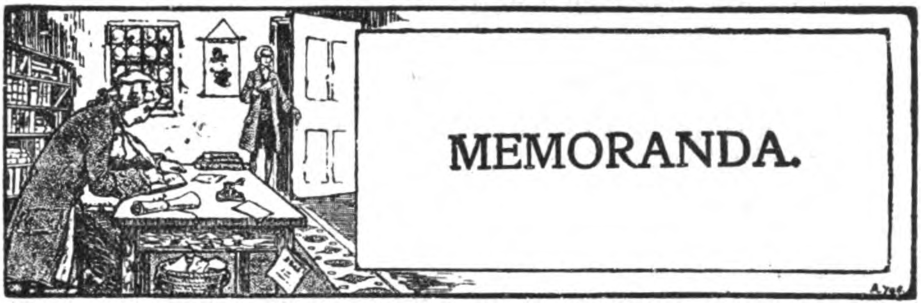
## MEMORANDUM.

**The Engineering Enquiry** (a new pocket-book for engineers).—The pocket-book entitled *The Engineering Enquiry*, compiled by Mr. Tomey Thompson, price 7s. 6d., is obtainable at all booksellers, or direct from the publishers, Messrs. J. W. Arrowsmith, Ltd., of Quay Street, Bristol, or Simpkin, Marshall, Hamilton, Kent & Co., Stationers' Hall Court, London.

Stated briefly, the volume specifies the requisite complete information which engineering manufacturers and sellers need in their enquiries. In this respect the volume is certainly exhaustive. Indeed, it tabulates, in similar numerical fashion, the requisite particulars applicable to enquiries covering the bulk of mechanical and electrical products and accessories.



PLANS AND ELEVATION OF SOME MINERS' COTTAGES IN COURSE OF CONSTRUCTION



# MEMORANDA.

*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Cement Asbestos Gutters and Down Pipes.**—In view of the present shortage of cast-iron gutters and down pipes the Ministry of Health will accept cement asbestos gutters and down pipes, subject to their being manufactured with properly prepared materials not less than three-eighths of an inch in thickness, and provided that the interiors of the gutters are painted as a precaution against decay.

**Concrete Cottages and Damp Courses.**—The Ministry of Health has informed the Guisborough Rural District Council that damp courses will not be required in concrete houses where the site concrete is sufficiently thick to prevent rising dampness from the ground underneath the house.

**Rapid Curing of Concrete Blocks.**—A method of rapidly curing concrete blocks adopted by the British Construction Co., Ltd., at Barnstaple, is described in *Vickers' News*. This company was engaged in the construction of concrete ships during the war, and a large plant was laid out for the manufacture of concrete bricks, tiles, posts etc., on an extensive scale. The blocks are made on machines in the usual way, and are then stacked in a soft state on wooden platforms, which are run into kilns. The kilns take the form of a series of tunnels with tight-fitting doors at each end, and in these the platforms are stacked one above the other. When the kilns are filled the doors are closed and wet steam, which thoroughly saturates the blocks, is injected. The blocks are left in a state of saturation for 48 hours, after which they are ready for handling. This plant is stated to be the only one of its kind in the country, and it is claimed that blocks treated in this manner are as hard in from seven to ten days as if they had been stacked in the open for over a month and soaked with water daily for ten or twelve days. A further advantage of this method of curing concrete is that the action of the steam frees it from salt.

**Concrete Roads in Denmark.**—We learn from *Engineering* that some official experiments with concrete roads have been undertaken in Denmark at the instance of the Viborg authorities on the Viborg-Aarhus high road. The experiments were carried on over a section some 350 m. in length and 4·5 metres wide, the camber being 1·50. The layer of concrete was 15 cm. thick, and it was strengthened with ribs 25 cm. broad and 10 cm. deep along the sides. The top layer, 5 cm. thick, was made of concrete with small stones ranging from 15 to 30 mm. in diameter, the mixture being 1 : 2 : 4 : whilst the formation layer was composed of gravel concrete mixed in the ratio 1 : 4 : 8. The top layer was placed upon the bottom layer immediately after the latter had been laid. For a short distance the concrete has been reinforced with light longitudinal and cross rods placed 7 cm. from the surface in a layer of concrete 10 cm. thick. Three weeks were allowed for the hardening of the concrete before the road was opened for traffic. One part was tarred immediately and the remainder was left for a period of nine months for observation. The concrete road, in spite of fairly heavy traffic, has shown no cracks, and, with the exception of a few isolated holes, about 1·5 cm. deep, it shows practically no signs of wear. The cost of the plain concrete portion amounted to 11·12 kr. per sq. m., the value of the old road material partly covering the cost of making up and removal ; the reinforcement cost an additional 3 kr. per sq. m., but the experiments have shown that the latter can be dispensed with under certain conditions.

**Restoring Hawser Piles with Concrete.**—The hawser piles used for tying up the big steamers, on the wharf at Old Point Comfort, Virginia, became decayed on one side until they were dangerously weak. The rotted part was all cleaned out carefully and the cavities filled with dense concrete, restoring the piles to their original shape and making them strong again.—*Concrete*, U.S.A.

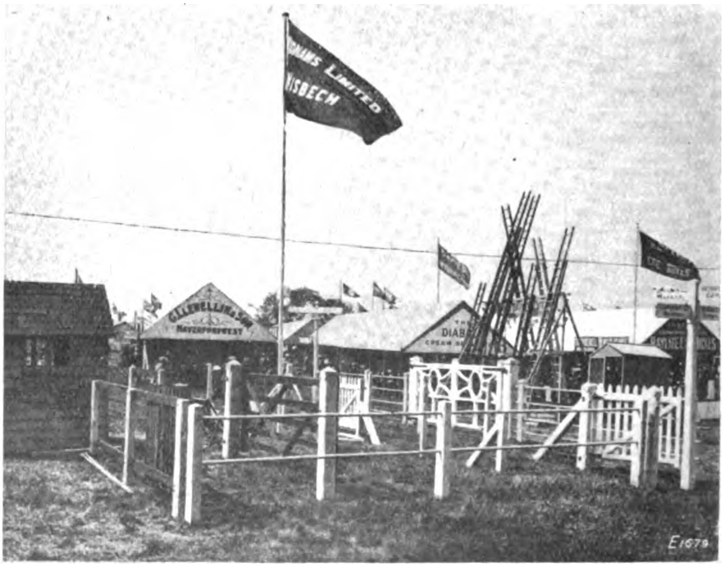
**Further Notes on the Concrete Exhibits at the Royal Show at Darlington.**—In addition to the exhibits mentioned in our previous notice of the Royal Agricultural Show at Darlington were those of the British Léan Co., whose block-making machine has already been described in CONCRETE & CONSTRUCTIONAL ENGINEERING. This, it will be remembered, is a machine of the spring ram type, the output of which, it is claimed, is about 800 blocks per day of eight hours when worked by two unskilled men and a boy.

On this stand, too, were exhibited types of the blocks moulded on this machine; and it is stated that a workman can wall in 20 super yards per day.

One of the sections of concrete walling exhibited at the stand of The Concrete Utilities Bureau was erected with British Léan blocks by the Victory Concrete Block Co., of Newcastle-on-Tyne.

On the stand of Messrs. Turner Bros. Asbestos Co., of Rochdale, excellent examples of the application of cement-asbestos sheeting to various structures were exhibited. These included garages, cart sheds, poultry houses and illustrations of the use of this material for interior linings.

Messrs. Tidnams, Ltd., of Wisbech, had a very attractive exhibit, which included various types of concrete fence posts for use with different kinds of fencing, ornamental gateposts with gates of various patterns in position, reinforced concrete signposts and concrete horse mangers. These exhibits are shown on the accompanying photograph, which gives a good idea of the excellent finish of all the articles displayed.



**Research.**—Among the new Research Associations which have been approved by the Department of Scientific and Industrial Research as complying with the conditions laid down in the Government scheme for the encouragement of industrial research, and have received licences from the Board of Trade under section 20 of the Companies (Consolidation) Act of 1908, are the following: The British Iron Manufacturers' Research Association, Atlantic Chambers, Brazennose Street, Manchester (secretary Mr. H. S. Knowles); the British Portland Cement Research Association, 6, Lloyds

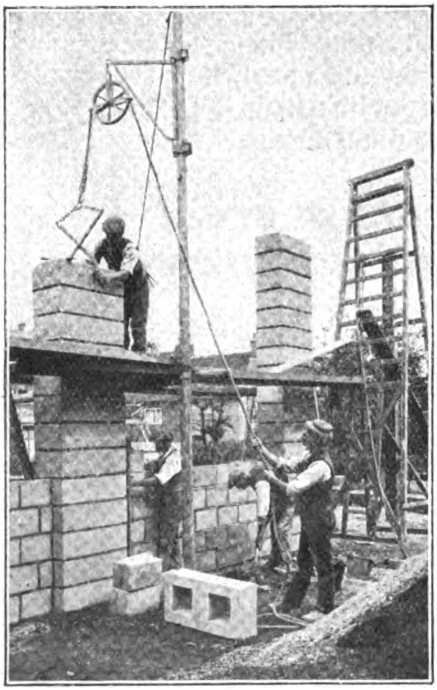
Avenue, London, E.C.3 (secretary, Mr. S. G. S. Panisset, A.C.G.I., F.C.S.) : the British Scientific Instrument Research Association, 26, Russell Square, W.C.1 (secretary, Mr. J. W. Williamson, B.Sc.). Schemes for the establishment of Research Associations in certain other industries have reached an advanced state of development.

The Secretary of the Department of Scientific Industrial Research announces that Professor John Bretland Farmer, D.Sc., M.A., F.R.S., Imperial College of Science and Technology, has been appointed by an Order of Council dated August 28th, 1920, to be a member of the Advisory Council for Scientific and Industrial Research.

**Concrete in Sewerage Work.**—Some large concrete works are being carried out in connection with the improvement and extension of the sewerage system at Sydney, New South Wales, which, when completed, will cost about £2,387,000. On the second section of the ocean outfall sewer, where it crosses Middle Harbour, a specially designed reinforced concrete inverted syphon is being constructed. The sewer itself will be 1,000 ft. long, and 45 ft. below low-water spring tide. It will consist of a double 6-ft. diameter reinforced concrete circular conduit, 10 in. in thickness, which is being constructed on the foreshore in 100-ft. lengths. These will be launched, floated into position, and lowered on to the foundations prepared ; the various lengths will be jointed together by spigot and socket joints, drawn and held together by bolts attached to cast-iron collars provided for the purpose.

## TRADE NOTES.

**Scaffold Cranes for House Building.**—The absolute need of saving labour and at the same time increasing the rate at which houses can be built has led many firms to devise special appliances for this purpose. A very useful device of this kind is the scaffold crane outfit designed and supplied by Messrs. Winget, Ltd., of 24, Grosvenor Gardens, Westminster. As will be seen from the accompanying illustration, the appliance is not only simple in construction, but easy to manipulate, and by its use the heaviest concrete blocks are handled and easily and rapidly placed into position.



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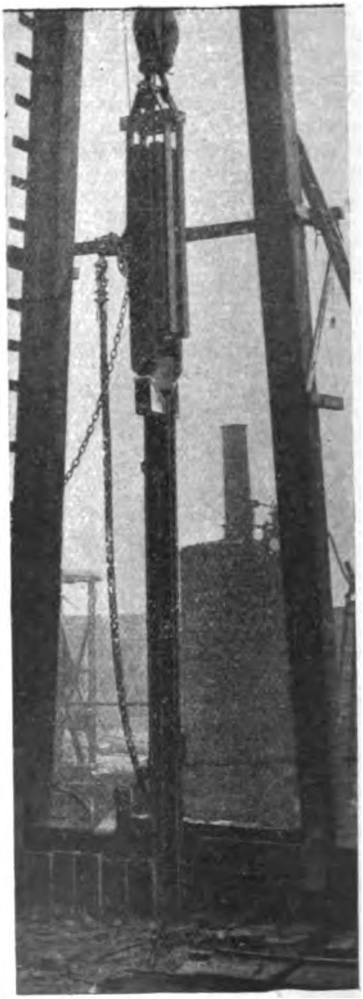


**Reinforced Concrete Road Foundations.**—We learn that reinforced concrete road foundation work is being carried out for the City of London Corporation at Finsbury Pavement and Houndsditch. B.R.C. Fabric is being used for the reinforcement in both instances.

**Roofing Material.**—The increased demand for roofing other than slates, tiles, corrugated iron, etc., has brought a number of substitutes on to the market. One of the latest of these is the ferro-concrete roof plate. In comparison with its strength, it is claimed that the ferro-concrete roof-plate is one of the lightest roof or wall coverings yet produced, combining all the advantages of corrugated iron without any of its disadvantages. It is imperishable, fire, fume and acid proof, artistic in appearance, cool in summer and warm in winter.

This roof-plate is formed of reinforced concrete longitudinal and cross ribs with a thin sheet of reinforced concrete between forming the body of the plate. The longitudinal ribs are reinforced by suitable rods, the cross ribs by wires, and the body of the plate by galvanised wire netting stretched between and secured to the main reinforcing rods. Two intermediate cross ribs are in each plate to act as ties between the longitudinal ribs. By dividing the plate into smaller panels the strength is increased. Expansion and contraction are provided for by filling joints with plastic material, and covering them with an independent concrete capping, which ensures absolutely watertight joints under all conditions. The slightly curved surface of the plate breaks the usual straight line and imparts to the roof a pleasing appearance.

Full particulars and prices can be obtained from the Ferro-Concrete Roof Plate Co., Govett Avenue, Shepperton-on-Thames, Middlesex.

## CORRECTION NOTE.

**The Economical Design of Reinforced Concrete Foundation Slabs.**—In reference to the article published in our September issue under this title, page 617, we would call attention to the following corrections :—

Page 617—(1) Top tier, $24 \times 30$ ft. = 720 lb.
Middle tier, $32 \times 80$ ft. = 2,560 lb.
Bottom tier, $140 \times 20$ ft. = 2,800 lb.

Total 6,080 lb.

(2) Last line but one should read : 10 ft. × 10 ft. This is clearly shown to be so in *Fig.* II.

Page 618—(3) Above Diagrams II. and III. should read : Take $t = 16{,}000$ lb./in.$^2$ and $c = 600$ lb./in.$^2$.

The first correction will necessitate an alteration under the heading (*a*) below the "advantages," near bottom of page 619. This should now read :—

"the enormous saving in the quantity of steel used (*i.e.*, $6{,}080 - 1{,}201 \cdot 6 = 4{,}878 \cdot 4$ lb. on 6,080 lb., or approximately 80·2 per cent.).

## TENDERS ACCEPTED.

### Housing.

NEWCASTLE-ON-TYNE.—The Town Council of Newcastle-on-Tyne has accepted the following tenders of Mr. H. Kelly for the erection of three types of houses : Type "C 2" (five-room parlour houses), £1,199 each in brick, and £1,154 on the "Duo" system of concrete construction ; Type "A X" (four-room non-parlour houses), £1,050 per house on the "Duo" concrete system.

LEEDS.—The Leeds Corporation has, subject to the approval of the Ministry of Health, accepted the tender of Messrs. H. Arnold and Sons, Ltd., for the erection of 222 concrete houses on the Harehills Estate, at £935 per house for Type "A" houses and £1,050 per house for Type "B" houses.

WHICKHAM.—The Whickham Urban District Council has accepted the tender of Mr. H. Kelly, of Leamington, for the erection of thirty pairs of houses at Swalwell, on the "Duo" system of concrete construction, at £1,846 per pair.

CONCRETE AND HOUSING SCHEMES.—The Northallerton Urban District Council has appointed a deputation to visit the concrete houses at Dormaston, with a view to the erection of similar houses at Northallerton. The Housing Committee of the Leake Rural District Council has reported that a firm specialising in concrete construction has offered to build concrete cottages at £700 each for non-parlour houses and £900 each for parlour houses. The Surveyor has been instructed to obtain tenders for houses in both brick and concrete. The Ashton-in-Makerfield Urban District Council has passed plans for the erection by the Lancashire County Council of two concrete houses in Billinge Road and six concrete houses in Rigby Street.

ST. AUSTELL.—The St. Austell Rural District Council has been recommended to accept the following tenders of the Banger Concrete Construction Co., Ltd., for the erection of concrete houses :—Eight houses on the Stenalees site, £7,070 ; eight houses on the Penwithick site, £7,437 ; 24 houses on the

Harmony Cottage site, £22,159 ; 46 houses on the St. Blazey-Trenovissick site, £43,003 ; and 42 houses on the Middleway site, £39,248.

Edinburgh.—The Housing Committee of the Edinburgh Corporation has accepted the tender of the Unit Construction Co., Ltd., for the erection of 360 concrete houses on the Wardie site, for a total sum of £406,246.

**General.**

Newcastle-on-Tyne.—It is reported that a tender amounting to £85,272 has been accepted for the construction of a reinforced concrete quay east of the Ouseburn.

Worsborough.—The Worsborough Urban District Council has accepted the tender of Messrs. Hodgkin and Jones, of Sheffield, for the construction of a reinforced concrete wall, for the sum of £1,123.

Stafford.—The Corporation of Stafford has accepted the tender of the Croft Granite Company for the supply of 400 yards of 24 inch diameter reinforced concrete tubes.

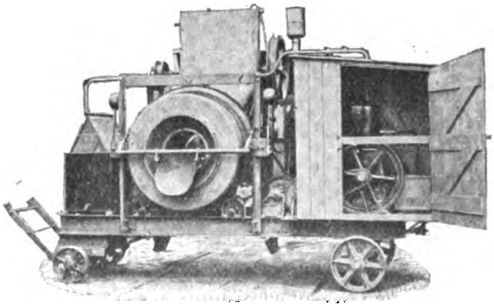
New Cooling Towers at Oldham.—The Oldham Town Council has passed plans for the erection of two cooling towers at Greenhill for the Electricity Committee.

## NEW COMPANIES REGISTERED.

Meldreth Lime and Cement Co., Ltd. (170,070). Registered September 4th, 1, Market Place, Peterborough. To carry on the business of lime burners and cement manufacturers. Nominal capital, £25,000 in £1 shares. Directors : J. S. Ellis, The Park, Peterborough ; C. W. Rowe, Orton, Longuville, Peterborough ; and E. H. Jellet, Eaton House, Wandsworth Common, S.W. Qualification of directors, £500 : remuneration to be voted.

## RECENT PATENT APPLICATIONS.

137,534.—F. L. Smith and Co. : Manufacture of cement.
147,983.—W. Wilson : Manufacture of faced concrete blocks.
148,050.—H. Banger : Hollow concrete blocks.
148,076.—G. Jaeger : Concrete mixing machines.
148,595.—L. S. Hatchard : Concrete blocks and their manufacture.
148,599.—W. J. Stewart and J. Woolcock.—Construction of reinforced concrete buildings.
131,909.—Müller Land und Industrie Bauten Akt.-Ges.: Hollow wall construction.
149,039.—L. Ennis and Dorman, Long and Co : Steel-framed cottage construction.
149,042.—C. Marques : Concrete block, slab, and tile making machine.
149,077.—G. L. Falconer : Concrete block moulding and pressing machine.
149,120.—E. Steiger : Cement and fibre sheet : flag and tile manufacture.
149,369.—J. M. Wellington and D. G. MacKenzie : Concrete block-making machines.
149,385.—W. J. Stewart and J. Woolcock : Reinforced concrete columns.
149,386.—W. J. Stewart and J. Woolcock : Reinforced concrete panels.
149,444.—F. W. Edlin : Building blocks and slabs.
149,484.—J. G. Ambrose and C. B. Matthews : Method of using building blocks.
149,511.—C. Marques : Concrete block-making machine.
149,538.—A. A. Byrd : Monolithic concrete construction.



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# CONCRETE AND CONSTRUCTIONAL ENGINEERING

**THE OFFICIALLY APPOINTED JOURNAL OF THE CONCRETE INSTITUTE**

**NOVEMBER 1920. VOL. XV. No. 11.**

***A MONTHLY JOURNAL for Engineers, Architects, Surveyors, and Contractors, and all interested in Cement, Concrete, Reinforced Concrete, Fire-Resisting Construction and Structural Steel***

*ISSUED MONTHLY*

## CONTENTS.

**Editorials.**

**An Interesting Cooling Tower Tank. Dalmarnock Power Station.**

**Erecting Tower for Concrete Work.**
By ALBERT LAKEMAN, M.S.A.

**Problems in the Theory of Construction: Calculations for Continuous Beams with Third-Loading.**
By EWART S. ANDREWS, B.Sc. (Eng.).

**Concrete Cottage Building.**
Meanwood Housing Scheme, Leeds.

**Proceedings of National Conference on Concrete House Construction, U.S.A.**

**Effect of Fineness of Cement.**
By DUFF A. ABRAMS.

**Concrete Piles.**

**Light Aggregate for Concrete Buildings.**
By A. W. STEPHENS.

**The Position of the Reinforcement in Concrete.**
By J. WAALKENS.

**Concrete Blocks for Lining Reservoirs.**

**Concrete in Theory and Practice.**
By OSCAR FABER, O.B.E., D.Sc.

**New Methods of Construction.**

**Porous Concrete.**

**New Books.**

**Questions and Answers Relating to Concrete.** **Memoranda.**

**THE CONCRETE INSTITUTE:**
**Monthly Notes, by the Secretary.** **Concrete Aggregates (continued).**

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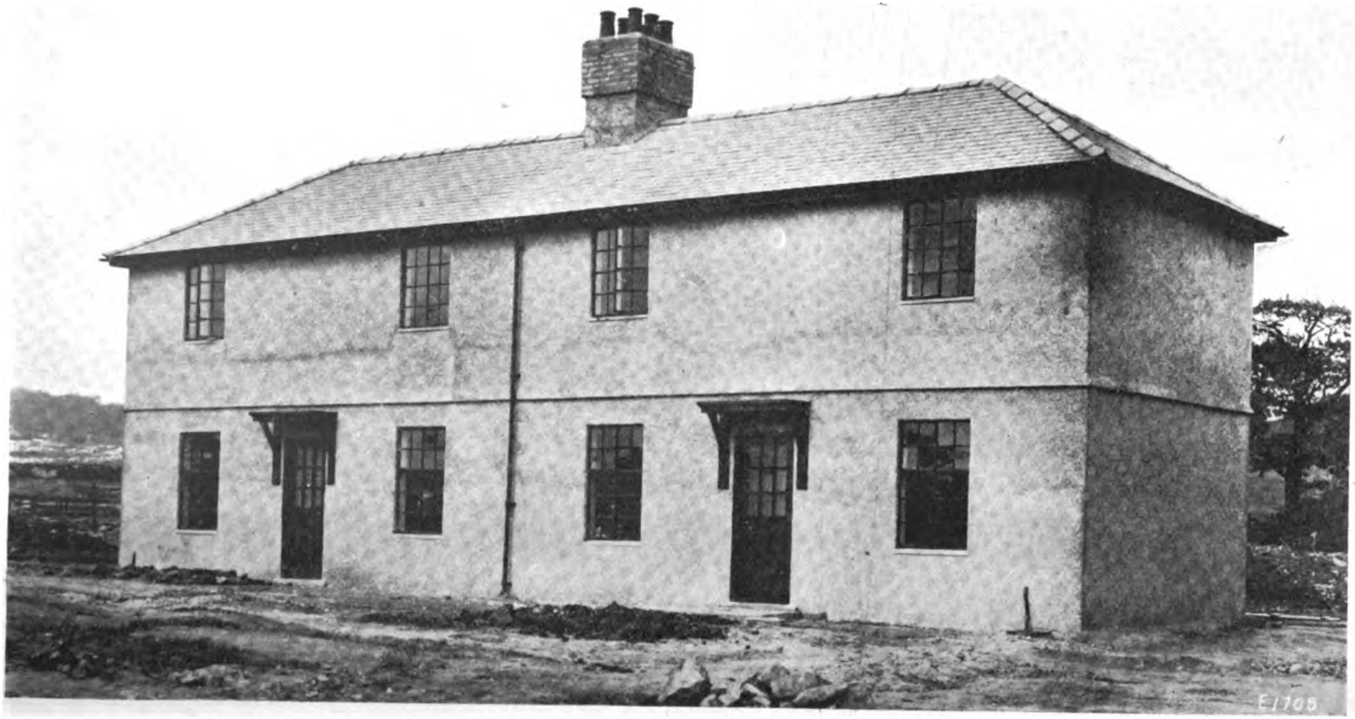

MEANWOOD HOUSING SCHEME.
*(For Description see page 737.)*

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume XV. No. 11. LONDON, NOVEMBER, 1920.

# *EDITORIAL NOTES.*

## THE FINENESS OF CEMENT.

It is a fact full of significance for the future of the concrete industry that research work on the properties of cement and concrete is now proceeding in so many laboratories in different parts of the world. It is true that most of these researches have a somewhat limited scope, and that the fundamentals of the subject are rarely touched, the experiments being mostly confined to the making and testing of trial batches of mortar and concrete under more or less exactly specified conditions, but a large amount of valuable information is being accumulated. One laboratory which is specially devoted to investigations bearing on this question is the Structural Materials Research Laboratory attached to the Lewis Institute, Chicago, and controlled jointly by that Institute and by the American Portland Cement Association, Chicago. We reproduce in this issue extracts from a report which has been published recently by the staff of that laboratory, dealing with the effect of fine grinding on the properties of cement. The improvement effected in the strength of cement by fine grinding is generally known, and commercial cements are now ground to a degree of fineness which would have been considered remarkable a few years ago. The new results show that the improvement brought about by finer grinding is chiefly marked in the leaner mixtures. For a given cement, there is a regular increase in the strength of mortars prepared from cement ground to an increasing degree of fineness The greatest increase is in the tests made after seven days, the differences being less marked, although still present, in the tests made after longer periods. This might be expected, as the hydration of cement particles is likely to require a longer time, the coarser the size of those particles. The finer cements set more rapidly, for the same reason, and they require a larger proportion of water to produce a normal consistence. The results obtained are independent of the nature of the aggregate employed. The degree of fineness is without influence on the expansion or contraction of the concrete after setting. It is important to note that the ratio of the weight of dry cement to its volume, usually called in this country the apparent density, varies widely with the fineness of grinding. Within the ordinary range of fineness, the weight of a given cement in the dry state decreases by ¾ lb. per cu. ft. for each 1 per cent. reduction in the residue on a 200 sieve. This should always be remembered in the proportioning of cement by volume. The author does well to call attention to this point, as there is often some confusion between proportions of cement by weight and by volume. Another point for notice is that differences in the quality of various mortars as shown by tests on cubes in compression are by no means always revealed by the tensile tests, an opinion which has been long held by many workers.

## VILLAGE SIGNS.

As our readers are aware, a competition was recently organised by the *Daily Mail* for designing village signs, the efforts of the competitors being subsequently exhibited at Australia House.

If this scheme and that of the Automobile Association for providing a continuity of road signs throughout the country materialises, as we hope it will materialise, a long-felt want will be met.

Before such a scheme is carried out consideration should be given to the material of which these signs or the posts supporting them are to be made in order to secure their permanence. Wood is liable to decay, iron needs painting at frequent intervals. Concrete, on the other hand, does not decay and needs neither paint nor preservative, and may be produced in any colour. Railway companies have taken advantage of these qualities of concrete for the construction of fence posts, telegraph posts, lamp posts, station name plates, gradient posts, and a host of other articles which were formerly made in wood or iron.

We suggest, therefore, that road signs, direction posts, and the posts for village signs could be made more efficiently and more economically in concrete than in any other material, and they would lose nothing in artistic effect.

## CONCRETE AND "LUXURY" BUILDING.

THE discretionary powers granted to local authorities under the Housing (Additional Powers) Act to prohibit any building operations which, in the opinion of the local authority within whose area the works are being or are proposed to be carried out, are likely to interfere with the supply of materials or labour which might otherwise be employed on housing work has resulted in the complete or partial stoppage of work on many buildings, and the abandonment or postponement of many other large schemes. These prohibition clauses have aroused considerable opposition on the part of the architectural profession, the building industry and those who propose erecting new or extending old premises. It is also very doubtful whether the desired result will be appreciably affected, as the majority of the skilled craftsmen employed on the type of building classed as " luxuries," such as stone and marble masons, steel workers and erectors, scaffolders, crane-drivers, plaster modellers, cabinet makers and wood carvers, and many others, are entirely unsuited for work on cottages.

Although many buildings have already been stopped, fortunately the final decision does not rest with the local authorities, as Appeal Boards have been set up. These Appeal Boards have frequently reversed the decision of local authorities by permitting the buildings to proceed providing that concrete is used in place of other materials. An instance of this kind recently occurred in Northampton, where the Corporation recently refused permission for alterations to a factory. The owners of the building gave notice of appeal, but we are pleased to learn from the Minutes of the Corporation that "consequent on negotiations this appeal had been withdrawn on terms that concrete blocks would as far as possible be used in construction in lieu of bricks . . ." The underlying intention of the Government is not the stoppage of building, but the prevention of labour being employed on work other than housing to the detriment of the latter, and if large buildings can be erected in concrete without hindering the urgently required housing schemes there should be no objection to their construction.

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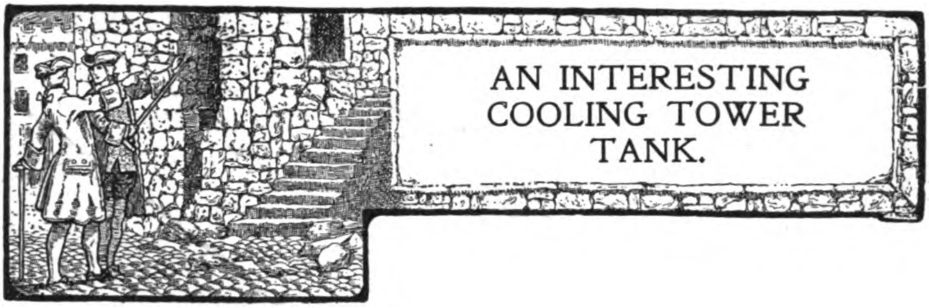
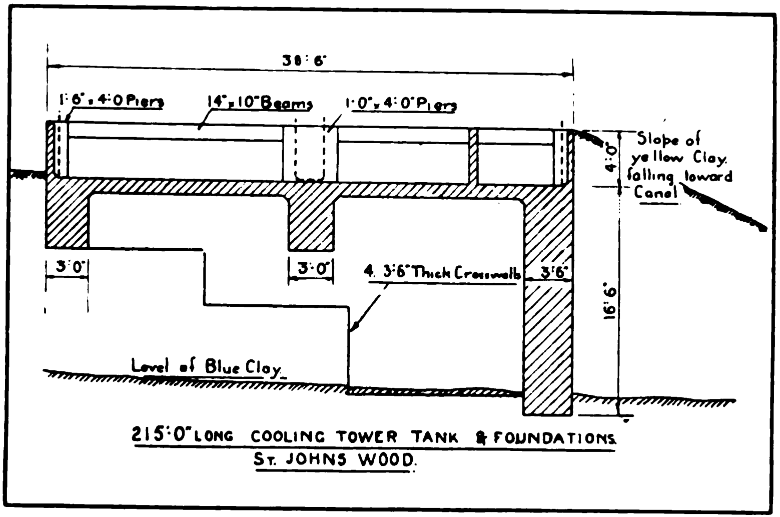


# AN INTERESTING COOLING TOWER TANK.

Owing to the difficult nature of the site, the construction of the cooling tower tank (illustrated herewith) at the St. John's Wood Generating Station of the Central Electric Supply Co., Ltd., presented unusual difficulties. The land belonging to the company is bounded on one side by a canal, and it is between this and the power station that several cooling towers have already been erected. The soil here is of soft yellow clay to a depth of 15 ft., below which is found the stiffer blue clay common to London subsoil generally at varying levels. Further, the restricted area between the generating station and the canal falls steeply to the water level. The cooling towers already erected occupy most of the available land, and, therefore, the new tower which has been found necessary had to be constructed quite close to the canal bank.

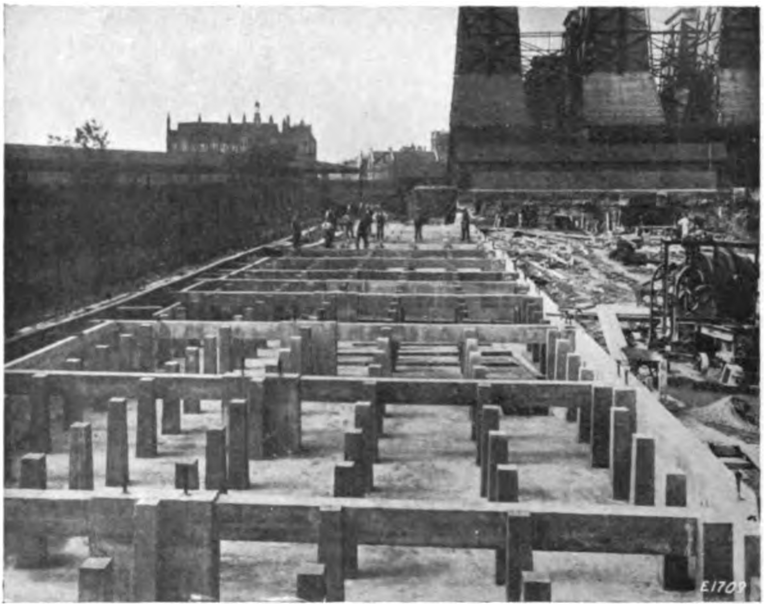


Reinforced Concrete Cooling Tower Tank at St. John's Wood: Cross Section.

In the case of the existing tanks, owing to their raft-like nature, no unusual difficulty was experienced, and they were constructed in the usual way with mass concrete, under the supervision of the Electric Supply

Company's architect, Capt. C. Stanley Peach, F.R.I.B.A. In the new tank, however, the effect of its weight on the soft foundation soil in conjunction with its juxtaposition to the canal bank had to be taken into account. It was considered that the usual construction would not suffice, and a firm of reinforced concrete engineers (Messrs. Peter Lind & Co., of 2, Central Buildings, Westminster, S.W.) was called in to carry out the work.

Two alternative methods of counteracting any tendency of the yellow clay to slip in the direction of the canal if the structure were built direct on this soft foundation were considered—viz., building the tank on piers sunk down to the blue clay and the construction of a retaining wall along the entire length of the side of the tank where it is contiguous to the canal bank. The latter method was decided upon as being more satisfactory and economical, and a retaining wall of reinforced concrete, 3 ft. 6 in. wide, has been constructed through the soft clay and 1 ft. 6 in. into the blue clay, a total depth from ground level of 16 ft. 6 in. As an additional safeguard two beams 3 ft. 6 in. deep by 3 ft. wide have been built projecting from the bottom of the tank, one along the side furthest from the canal and one along the centre.

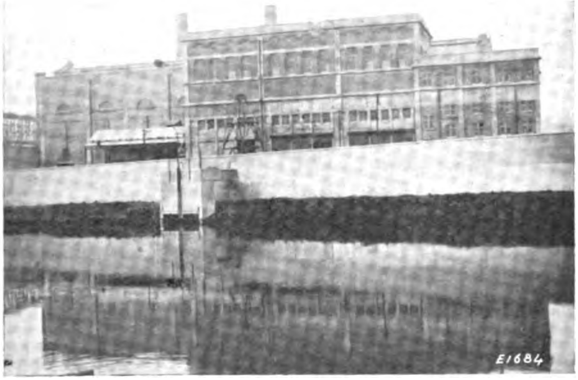


Reinforced Concrete Cooling Tower Tank at St. John's Wood.

Excavations are now in progress for further cooling towers immediately behind this one, and, owing to the presence of the retaining wall, it will be possible to build these without reinforcement. The walls, beams, stack-piers, etc., of the new tank, which is 215 ft. long by 38 ft. 6 in. wide by 4 ft. deep, are of ordinary construction, and the tank will receive the cooled water from three towers, which are now in course of erection. The photograph was taken immediately on completion of the tank, and the section clearly shows the retaining wall and projecting concrete members below the tank. We are indebted to the Electric Supply Company's engineer, Mr. H. T. Gaze, A.M.Inst.C.E., for his courtesy in giving us facility for inspecting the work.

# DALMARNOCK POWER STATION, GLASGOW.

With the formal opening of Dalmarnock Electricity Station, Glasgow, the corporation of that city are now in possession of a super power station planned on the most modern lines. In January last we published an article on this Glasgow station, before the buildings were completed. We now give photographs showing the station buildings from the south and from the south-west.

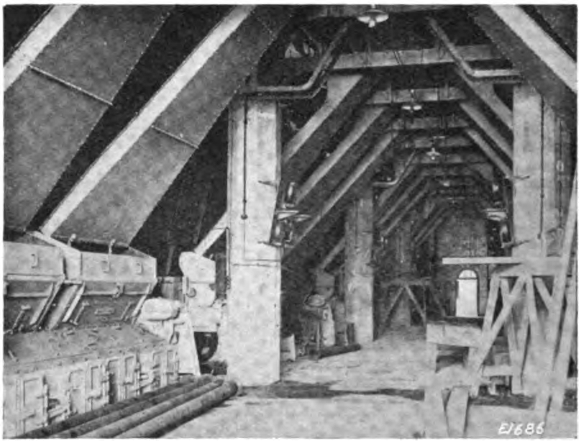


Station Buildings from South Switch House and Condensing Water Inlet.
Dalmarnock Power Station, Glasgow.

The ground measures 13½ acres, and is bounded on the south by the River Clyde, which ensures an ample supply of condensing water. There are two main sections; each section comprises coal store and coal conveyors, two boiler rooms, turbine room, switch house, workshop, control room, and sub-station. Reinforced concrete is the building material, from designs by the Considère Construction Company, and the Glasgow Electricity department's staff, Messrs. Merz and McLellan, acted in an advisory capacity. The ultimate electrical load will be 200,000 kw.

To ensure absolutely sound foundations a concrete raft about 5 ft. thick was laid over the whole area of the boiler house, turbine room, and switch house. In the photographs are shown the inlet and outlet for the condensing water, which has screening plant.

Very substantial is the coal house. Each railway truck from the coal pits passes over a weigh-bridge to a tipping platform. The truck is emptied into a filler pit by an electrically operated ram. Bucket conveyors convey the coal where wanted. The capacity of the plant is 100 tons per hour. Suction plant removes the ashes. The boiler house is a three-storey building: ground floor, forced draught fans and motors and ash removal hoppers; first floor, boiler room; top floor, reduced draught plant, economisers, coal silos and hot wells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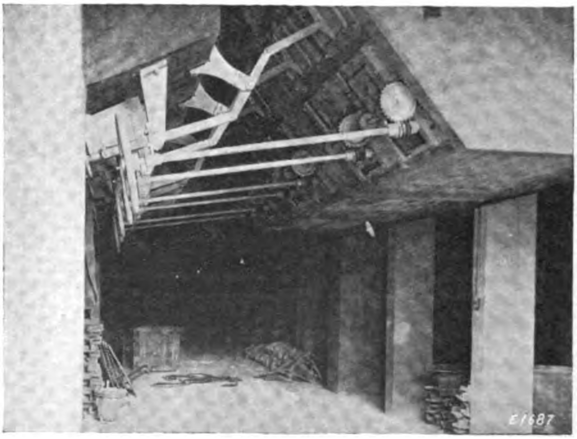
Boiler House.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Ash Tunnel.
Dalmarnock Power Station, Glasgow.

Dimensions of the turbine room: length, 264 ft.; breadth, 75 ft.; height, 65 ft. The condensate is pumped from each condenser through a

Lea recorder. Two 75-ton travelling cranes are installed; one spans the turbine room, and one is in the workshop. The switch house is of large size; all the switches are operated from a control room. In the basement are storage batteries. Every allowance had to be made for heavy weights —boilers, turbine, alternators and condensers. Each turbo-alternator is of 24,000 h.p., and the maximum output of each boiler is 62,000 lb. of steam per hour.

Station Building from South-west. Switch House on right.
DALMARNOCK POWER STATION, GLASGOW.

Contractors for the reinforced concrete work, Messrs. John Train & Taylor; for the steel construction work, Messrs. Redpath Brown & Co., Ltd.; and for the coal conveyors, etc., Messrs. Babcock & Wilcox, Ltd.

## MEMORANDUM.

**New Building Services in France.**—According to *La Nature*, the shortage of workers and the pressing need of buildings in the Departments devastated during the war has led to new devices in which the saving of time and the reduction of hand labour are prominent. In the process of M. Ch. H. Besnard, an architect of the Government, elements of reinforced concrete are moulded in the factory under favourable conditions of temperature and humidity, where workmen are on the ground and not in mid-air, and where inspection and tests can be carried out with satisfaction. In erection a skeleton, consisting of posts, carrying at the upper end very stout metal gutters, and horizontal girders connecting the posts, is put up. The gutters themselves serve as lengthwise girders. From the peak of the roof descend the two sloping sides of glass or of tile, and both rest upon the inner edges of the gutters on the two sides of the structure. Outside of the actual elevation of the members and of their fixing in place, but little work need be done at the site of the structure. The roof has only three joints. The same process is applied to dwelling houses as well as to factories.

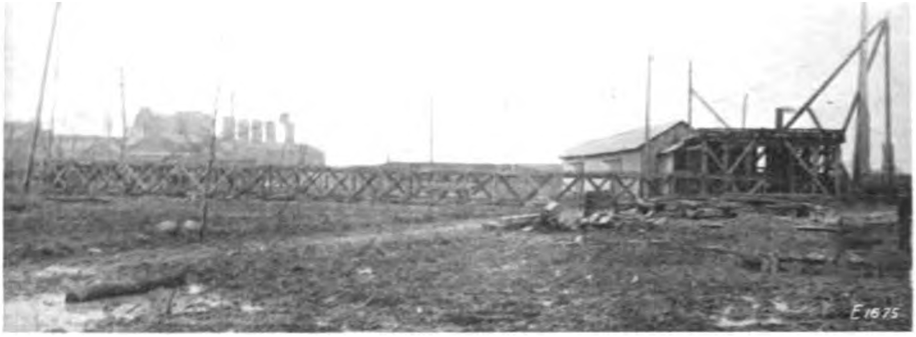


FIG. 1. TOWER ON GROUND, READY FOR RAISING.

# ERECTING TOWER FOR CONCRETE WORK.

## By ALBERT LAKEMAN, M.S.A.

THE use of towers for chutes in connection with the execution of concrete work is very general in America, and they are installed on practically all large schemes, although there has always been considerable difference of opinion amongst engineers as to the advisability of placing concrete in important work by means of chutes. There is no doubt, however, that considerable time and money can be saved where towers and chutes can be adopted if a large amount of work has to be done. Some interesting photographs are here given which illustrate the installation of a wooden tower 150 ft. high for the purpose of pouring concrete on a large contract in Buffalo, New York, U.S.A. The total amount of concrete to be executed was over 76,000 yd cu., and three towers were installed with hoists and chutes to each one. The towers are about 6 ft. sq. on plan, and they are built up with 6 in. by 6 in. posts at the corners, and 6 in. by 2 in. braces and cross-pieces. The tower is divided up into panels about 6 ft. in height to allow the braces to be at an angle of 45 degrees with the horizontal and vertical members. The chief interest lies in the fact that these towers were built on the ground complete, and then raised into position by wire ropes with the necessary pulleys, and all the joints were made with *nails* only, no bolts being used in the main structure, except for bolting the hoist guides. The corner-posts are necessarily jointed, and where joints occur the ends are simply butted together and wooden fishplates are nailed on to make the connection. Engineers will appreciate the judgment that has to be exercised in raising a wooden-framed structure 150 ft. high wherein the connections are made solely by the use of nails, as any appreciable deflection caused by the weight of the tower would result in the nails being drawn, with consequent collapse. The maximum time required for raising from the ground to the vertical position was three hours, and in one instance the operation was successfully carried out in one and one half hours. The foot of the

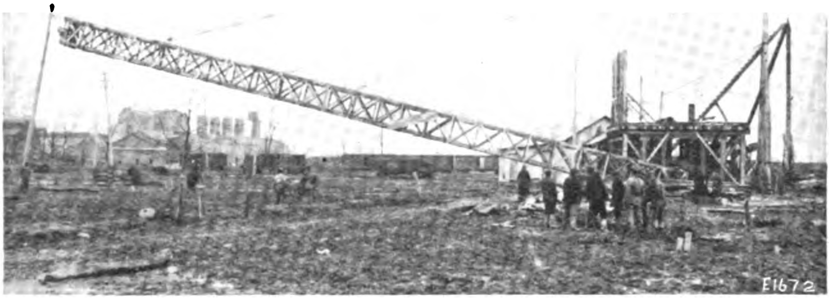


FIG. 2. FIRST STAGE OF RAISING TOWER

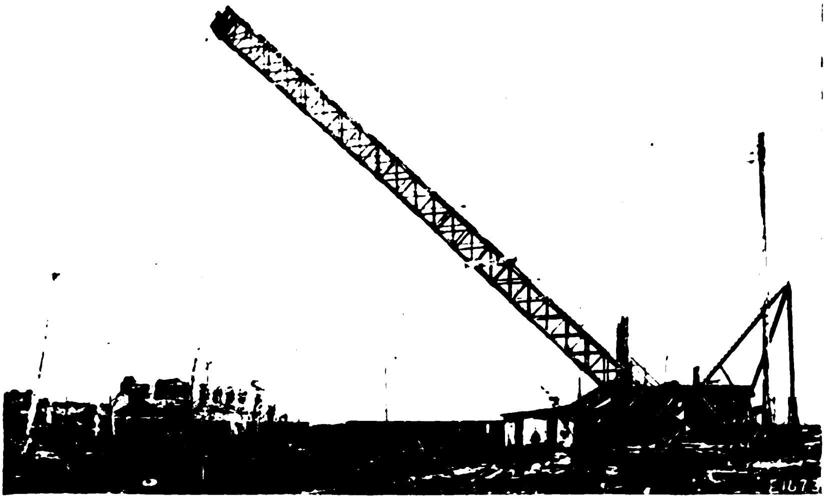
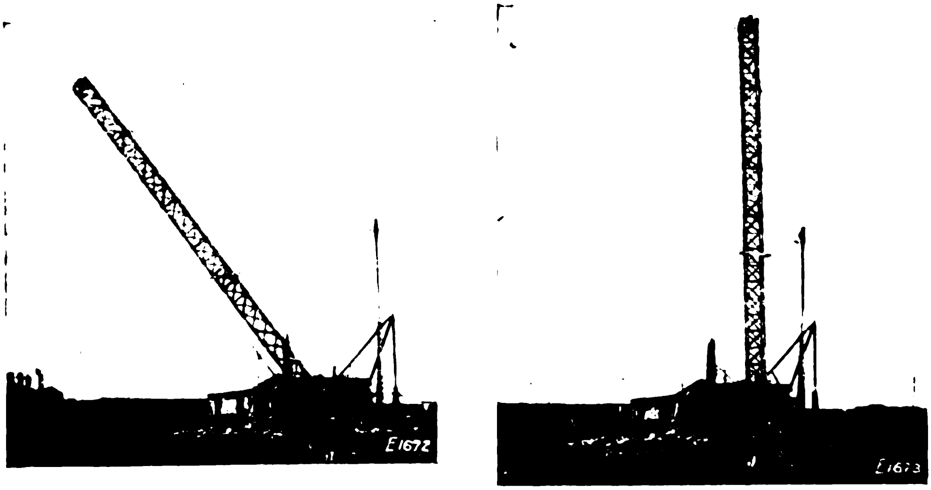


FIG. 3. SECOND STAGE OF RAISING TOWER.

tower requires to be securely anchored to take the inclined thrust, having a varying angle at the different stages, and this was accomplished by wire ropes attached to anchor-bolts concreted in below the ground-level. The tower is carried on a concrete foundation, which is formed to give a suitable pit to receive the hoisting skip, and a safety recess is provided in conjunction with this pit to enable a workman to remove any surplus concrete spilled over without danger.

In *Fig*. 6, which indicates the tower in position, it will be noticed that a large bin is provided for the storage of aggregate, and this was kept filled by a steam hoist and derrick, which took the material from the railway cars direct with a clam-shell or bucket and deposited it in the bin. Immediately below the bin a platform was arranged with the mixer, and the aggregate was discharged by means of a hopper from the bin into the mixer hopper, and the cement storage sheds were arranged alongside with conveyer belts from same to the mixing plat-



Figs. 4 and 5. Third and Final Stages of raising Tower.

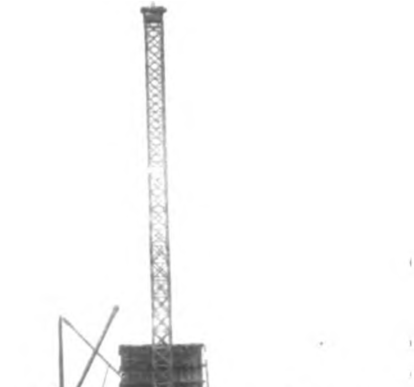


Fig. 6. The Tower in position with Aggregate Bin.

form ; thus the handling of the materials into the mixer was extremely simple and expeditious. The capacity of the hoist in the tower was sufficient to take one yd. cu. of mixed concrete, and the output from one plant of this kind was over 400 yd. cu. per day on several occasions. After the concrete was hoisted to the required level it was discharged into a steel hopper from whence it flowed by gravity, in metal chutes, to the required position. Great care was taken in tamping the concrete in position to prevent any defects due to the possible separation of the large particles from the matrix, and test cubes taken at various points on the work show a concrete of excellent quality. It is interesting to note that the timber towers were subjected to a severe gale at one time, when the velocity of the wind reached 75 miles per hour, but the guy ropes held the structures in a satisfactory manner, and no movement or defect occurred.

## MEMORANDUM.

**Tests of Concrete in Tension.**—In a recent issue of *Engineering News-Record* Messrs. T. H. Carver and J. H. Quense, water supply engineer and assistant engineer of Seattle, Washington, gave an account of some large-size tests carried out by them with concrete briquettes in connection with a reinforced concrete pipe line for the City of Seattle. Though they have not been extensive enough to establish general rules, the results are presented for such value as they may have in the design of reinforced concrete structures of rich, high-grade concrete when it is desirable that sufficient steel be used to prevent tensile cracking of the concrete at mixing loads.

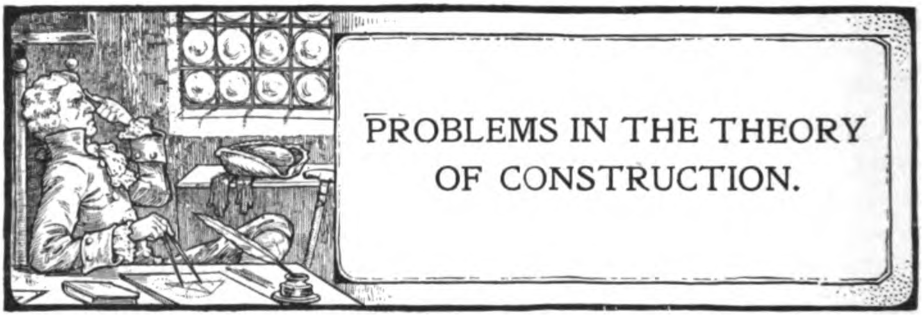
The specifications for the concrete pipe called for concrete mixed in the proportion of one part cement to 1½ parts sand and 2½ parts gravel, but the contractor elected to add 21 lb. of cement to each batch, making a mixture of 1 : 1·42 : 2·36, a barrel of cement being considered to be 3·5 cu. ft.

Test briquettes were made in the yard where these pipes were cast, the concrete being taken from the regular mix. In all ten briquettes were made and tested at ages from 57 to 609 days. The cement was subjected to the usual laboratory tests. Briquettes of one part cement and three parts standard Ottawa sand developed an average strength of about 330 lb. in seven days and 490 lb. in 28 days. Sand and gravel were of first-class quality, clean and carefully graded.

While the curve of the total mixture as used resembles Fuller's curve in general form, it was found necessary to use a larger percentage of small gravel. The amount of water used was carefully controlled and averaged about 19·5 per cent. by weight. Concrete was machine mixed in four-sack batches, each batch remained in the mixer three minutes, the machine running at the rate of 16 turns per minute.

A general summary of ten of the tests is given in the following table :—

| Specimen. | Age at Test Days. | Breaking Load lb. per sq. in. | Average Modulus of Elasticity. | Extensometer Removed at lb. per sq. in. |
|---|---|---|---|---|
| A2 | 58 | 268 | 5,030,000 | 97 |
| B3 | 57 | 333 | 5,830,000 | 107 |
| C2 | 60 | 278 | 5,996,000 | 189 |
| C3 | 234 | 378 | 5,870,000 | 269 |
| F1 | 585 | 445 | 4,904,000 | 207 |
| F3 | 609 | 492 | 5,785,000 | 342 |
| G1 | 562 | 473 | 4,952,000 | 187 |
| G2 | 565 | 480 | 4,918,000 | 337 |
| G3 | 566 | 431 | 4,772,000 | 380 |
| G4 | 567 | 430 | 5,140,000 | 380 |



## CALCULATIONS FOR CONTINUOUS BEAMS WITH THIRD-POINT LOADING.

By EWART S. ANDREWS, B.Sc.Eng.

In designing reinforced continuous concrete beams it is necessary to consider the maximum bending moments that can occur whether the spans are loaded or not. The accepted method of determining the bending moments in a continuous beam is by means of the Theorem of Three Moments, which is expressed by rather a complicated formula, the mathematical symbols of which often succeed in frightening designers into the belief that the subject is beyond their understanding, because the great and awe-inspiring " higher mathematics " are involved.

In many cases of continuous beams it is a matter of some considerable difficulty satisfactorily to derive the results without a great deal of arithmetic, but we wish to impress upon our readers that it is arithmetic and not advanced mathematics that is involved.

We propose in the present articles to deal at length and in as simple a method as possible with the case, which commonly arises in practice, in which secondary beams run into main beams at the " third-points "—*i.e.*, at points which divide each of the main beams into three equal parts.

(1) Two equal spans.—The case in which the main beam has two equal spans arises frequently in practice in industrial buildings and is the easiest of treatment.

*Fig.* 1 represents part of the framing plan of a building in which the arrangement of the beams is in accordance with the case under consideration.

The continuous main beam $L\ C\ R$ consists of two equal spans of length $l$ and secondary beams of length $l^1$ run in at the third points $a$, $b$.

Now let $w_s$ = superload per unit area of floor slab (in addition to dead load)

$w_d$ = dead load per unit area of floor slab

and let $W_a$, $W_b$ be the loads at $a$ and $b$ when the corresponding side of the floor is loaded and $W^1_a$, $W^1_b$ be the corresponding loads when the floor is unloaded.

Then we may take the following values :

$$W^1_a = 1{\cdot}1\ w_d\ .\ l^1\ .\ \frac{l}{3} + \text{weight of secondary beam}$$

$$W^1_b = w_d\ .\ l^1\ .\ \frac{l}{3} + \quad ,, \quad ,, \quad ,,$$

$$W_a = W^1{}_a + 1{\cdot}1\, w_s l^1 \frac{l}{3}$$

$$W_b = W^1{}_b + w_s l^1 \frac{l}{3}$$

These values are based upon the assumption that the reaction on the penultimate supports of the floor slabs are increased by 10 per cent. due to the continuity of the slabs. We will give in an appendix, as a matter of interest, a derivation of formulæ to a greater degree of accuracy, but for most practical calculations the above values are sufficiently accurate.

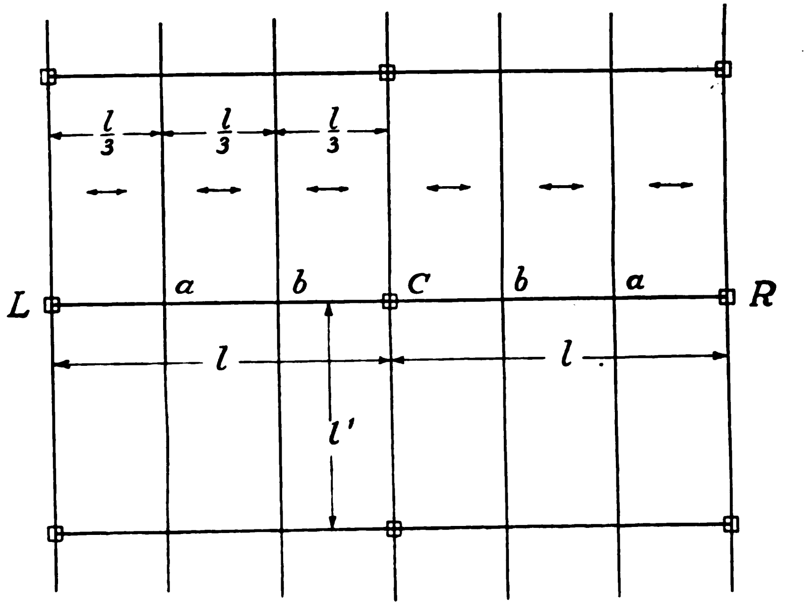


Fig. 1.

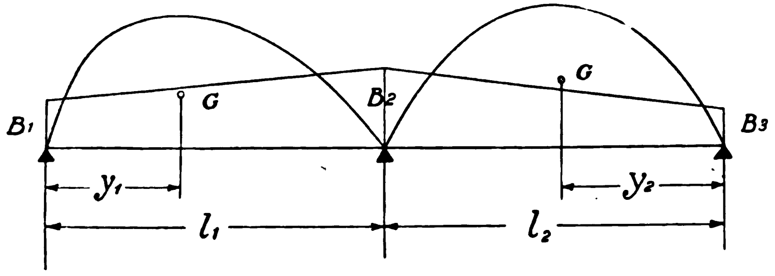


Fig. 2.

CENTRAL SUPPORT BENDING MOMENT DUE TO LOADS ON ONE SPAN ONLY.—We will now show how the central support bending moment at the point $C$ can be calculated separately for the load on the two spans.

Referring to *Fig.* 2 we may state the Theorem of Three Moments by the following mathematical relation between the reverse or support bending moments at three successive supports of a continuous beam, the levels of which remain constant :

$$B_1 l_1+2B_2(l_1+l_2)+B_3 l_2=6\left\{\frac{A_1 y_1}{l_1}+\frac{A_2 y_2}{l_2}\right\} \qquad (1)$$

where :—

$B_1$, $B_2$, $B_3$ = bending moments (negative) at supports.

$l_1$, $l_2$ = lengths of successive spans.

$A_1$, $A_2$ = areas of the " free " bending moment diagrams on the two spans—*i.e.*, the diagrams which would arise with separate simply supported spans.

$y_1$, $y_2$ = distances of the centroids of these diagrams from the supports 1, 3.

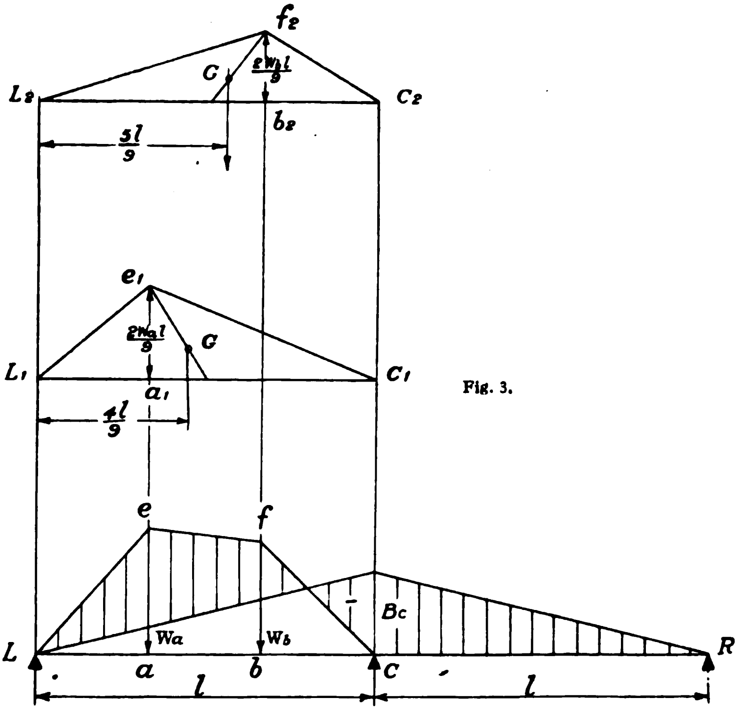


Fig. 3.

We will note that :

$A_1 y_1$ and $A_2 y_2$ = 1st moments about 1 and 3 of the " free " B.M. diagrams.

Now referring to *Fig.* 3 we will take loads $W_a$, $W_b$ on the left-hand span separately.

The free B.M. diagram due to $W_a$ is the $\triangle L_1e_1C_1$, the height $a_1 e_1$ being equal to $\frac{2W_a l}{9}$; the area of this $\triangle$ is equal to $\frac{1}{2}\cdot e_1a_1\times L_1C_1=\frac{W_a l^2}{9}$ and its centroid is at the point $G^1$ at distance from $L_1$ equal to $\frac{l}{3}+\frac{2}{3}\cdot\frac{l}{6}=\frac{4l}{9}$.

Therefore the 1st moment of this $\triangle$ about the point $L_1$ is equal to :

$$\frac{W_a l^2}{9}\times\frac{4l}{9}=\frac{4W_a l^3}{81}$$

Similarly the free B.M. diagram due to $Wb$ is the $\triangle\ L_2f_2C_2$, the area of which is equal to $\frac{W_bl^2}{9}$ and the centroid $G$ of which acts at distance $\frac{5l}{9}$. Therefore the 1st moment of this $\triangle$ about the point $L_1$ is equal to $\frac{5W_bl^3}{81}$.

These two $\triangle$'s when combined give the free B.M. diagram $LefC$.

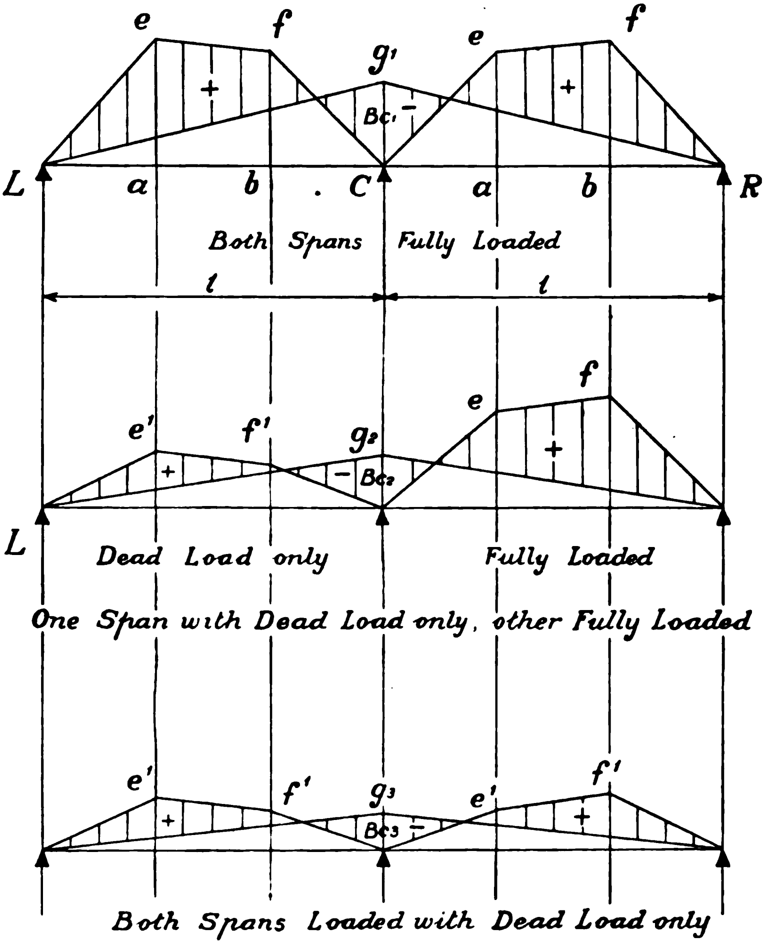


Fig. 4.

The ‘ free ” reactions at $L$ and $C$ due to these loads will be equal to :

$$r_L=\frac{2W_a}{3}+\frac{W_b}{3}=\frac{(2W_a+W_b)}{3} \qquad (2)$$

$$r_c=\frac{W_a}{3}+\frac{2W_b}{3}\quad\frac{(W_a+2W_b)}{3} \qquad (3)$$

$$\therefore\quad ae=r_L\times\frac{l}{3}=(2W_a+W_b)\,.\,\frac{l}{9} \qquad (2a)$$

$$bf=r_c\times\frac{l}{3}=\frac{(W_a+2W_b)\,.\,l}{9} \qquad (3a)$$

Now let us return to equation (1) which represents the theorem of three moments. In our case $L$ and $R$ are free supports, so that $B_L = B_R = 0$, and $l_1 = l_2 = l$; also there is no load on the second span, so that $A_2 = 0$.

We therefore have :—

$$4B_c \, . \, l = 6\frac{A_1 y_1}{l} .$$

$$= \frac{6}{l}\left\{\frac{4W_a l^3}{81} + \frac{5W_b l^3}{81}\right\}$$

$$\text{i.e.,} \quad B_c = \frac{l}{54}\{4W_a + 5W_b\} \qquad (4)$$

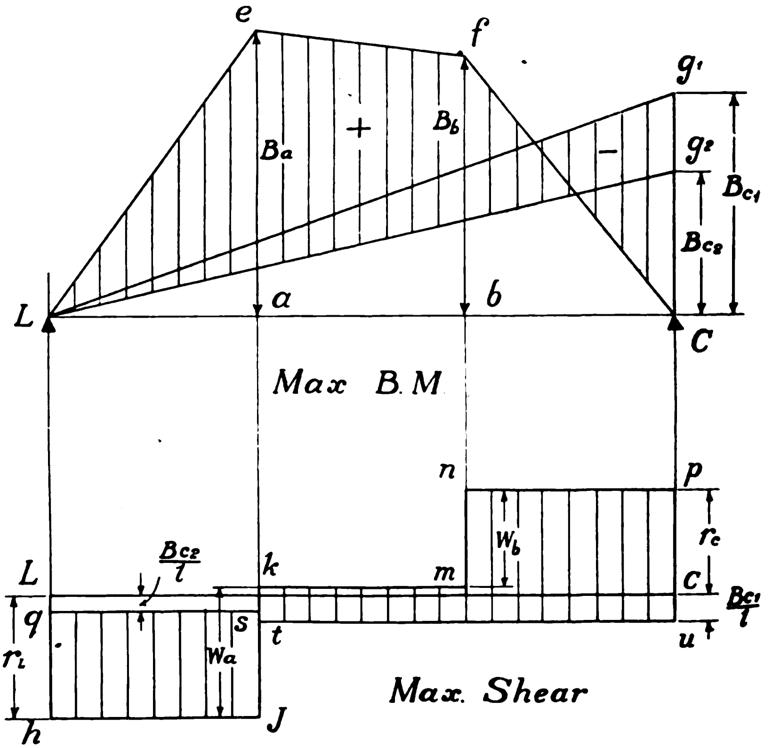


Fig. 5.

This is the central B.M. caused by the loads $W_a$, $W_b$ on one span only; if we have loads $W^1_a$, $W^1_b$ on the other span we shall have, due to them acting alone :

$$B_c = \frac{l}{54}\{4W^1_a + 5W^1_b\} \qquad (5)$$

so that when the two loads act together we get :—

$$B_c = \frac{l}{54}\{4\,(W_a + W^1_a) + 5\,(W_b + W^1_b)\} \qquad (6)$$

(*To be continued.*)

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# CONCRETE COTTAGE BUILDING.

## MEANWOOD HOUSING SCHEME, LEEDS.

One of the largest contracts for concrete cottages at present in progress in England is one on the Meanwood Estate for the Leeds Corporation. The number of houses in the contract is about 800, and the contractors are Messrs. William Airey and Son, Ltd., the system employed being that known as the " duo slab " system.

In a scheme of this magnitude it is obvious that, in order to effect the utmost economy, considerable organisation is necessary so as to eliminate all superfluous handling of material and parts. It is, perhaps, insufficiently realised that each additional handling of a building unit or material—be it a brick or concrete slab, timber for carcassing, or joinery—represents wasted labour, and therefore adds to the cost of the structure. It often happens that with concrete blocks the various processes entail many handlings. Thus, the mixture must be placed in a machine and tamped ; the block is then moved on its pallet to a drying rack. After a few days it must be moved from the pallet, and then finally it must be taken to the site of the building operation. One of the chief advantages of the system that is organised at Leeds is that most of these processes are eliminated. The blocks are made in sets of 36 on the actual spot where they will be required, and they are left there to season, so that after the mixture has been placed in the mould and tamped it is not handled again until it is built into the house.

In order that the maximum advantage may be taken of the standardised block sizes it becomes necessary to build as far as possible to a block unit size. This constitutes, as has often been pointed out in former articles dealing with this matter, a distinct handicap. In this particular system it becomes necessary to work to 4 ft. centres in length and 8 in. courses in height.

The blocks are made in a skeleton wood moulding frame formed out of 2¾ in. by 2½ in. stuff and measuring 3 ft. 7 in. long and 2 ft. 2 in. wide. This frame is hinged at three corners and latched at the fourth, and is laid on a similar-sized wooden platform near the site of the proposed house. The frame is, furthermore, divided into three compartments, each 3 ft. 7 in. long by 8 in. wide, by means of two moveable wooden slips, 3 ft. 7 in. by 2¾ in. by 1 in. See *Fig.* 1. On the top of this moulding frame is laid a screeding frame, which makes the total depth 3¾ in. The three compartments are then filled with the mixture, which is composed of crushed clinker (from the gas works) and cement mixed 6 to 1. After the

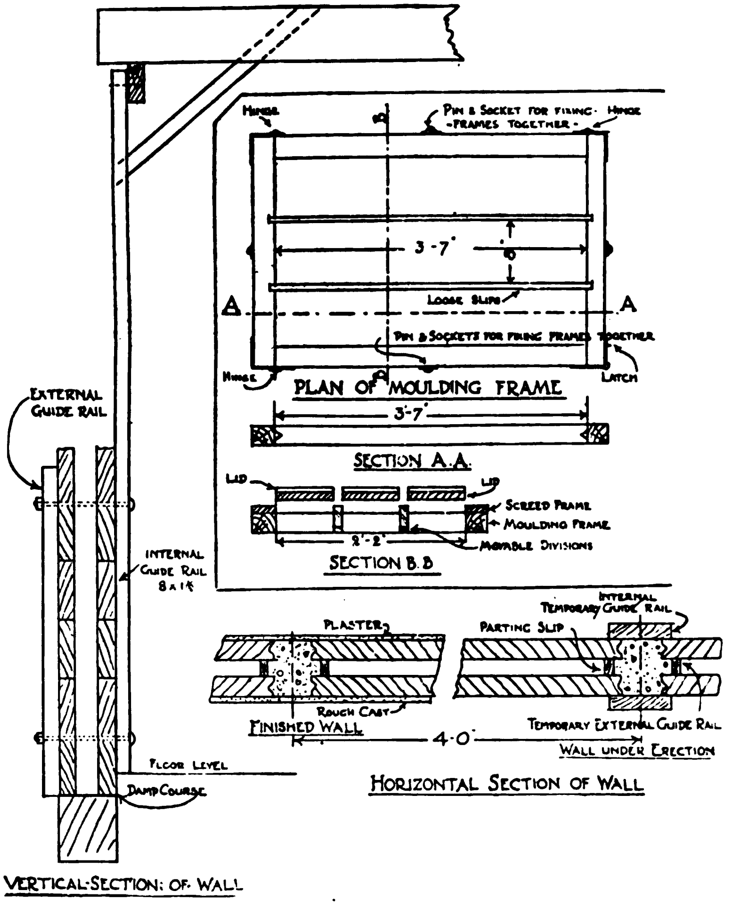


Fig. 1. The "Duo Slab" System of Construction.

concrete is roughly levelled off, a lid is placed on it with rebated edges; upon this a workman stands and rams it down on to the frame, compressing the 3¾ in. of concrete to 2¾ in., that is, down to the level of the original frame without the screeding frame. This lid, together with the screeding frame, are then removed and the blocks are covered with a sheet of paper or sprinkled with sawdust. At the top of each moulding frame there are 4 sockets, one in the centre of each side, and into these corresponding spigots fit, which are attached to the underside of the frames. In this way 12 frames are filled in succession on top of each other, making batches of 36 blocks in each pile, the top ones being finished before the initial set of the first block has taken place. As soon as a batch is completed the 12 moulding frames are unlatched and removed in readiness for another filling, and the spacing fillets are withdrawn. The paper or sawdust prevents the blocks adhering to each other, and retains the moisture, so that no sprinkling is performed. The ends of all the blocks are grooved. *Fig.* 2 shows the blocks stacked up on the site. About 900 are used on each house.

### METHOD OF CONSTRUCTION.

The method of construction is interesting. Solid foundations are brought up to within 3 in. of the floor level; and at this point the usual damp-proof course is laid. The blocks are laid in position by means of vertical guide rails. These are spaced at 4 ft. centres along the internal faces of the wall, with a wall plate at their tops. The whole is made rigid by the floor joists, which are fixed in position at this stage. External guide rails, which are only 4 ft. in length, are bolted with 28 in. bolts to the internal rails. The dimensions of the rails are 8 in. by 1½ in. by 8 ft. for the interior, and 8 in. by 1½ in. by 4 ft. for the exterior. See *Fig.* 1. The method of erection is to lay the blocks dry on their edges between the guide rails, forming a hollow wall with a 2 in. cavity. A 2 in. by 1 in. parting slip is placed in the cavity at the ends of the blocks and the space between these slips and the guide rails is run in with clinker concrete. The laying of the blocks is claimed to be extremely rapid; two men lay 10 sq. yd. per hour, which is said to be equivalent to 1,000 bricks. The blocks weigh about 40 lb. each. As soon as the blocks are laid to the level of the outer guide rail, viz., 4 ft., the lower bolt is loosened and the guide rail swung up, so that the former top bolt becomes the lower one in the new position. This brings the building up to first floor-level, and then the joists are dropped into position. The guide rails can then be removed and the operation repeated for the first floor. The window and door frames are built in between the piers as the work proceeds. The walls are finished with cement and sand stucco. Various experiments have been carried out on the walls to test their weather-resisting qualities, and the results are claimed to have been altogether satisfactory. Tests for strength have also been carried out, and the blocks have fractured at 2½ cwt. by being placed on edge over three foot supports and loaded at the centre. Crushing tests have also been made.

The illustrations show the work in various stages of progress. *Fig.* 3 shows a group of houses under construction. The first-floor level has been reached. The method of dropping the blocks into position is clearly shown, and of building in the door and window frames. *Figs.* 4 and 5 show the work on the upper storey and on the roof, while *Fig.* 6 shows a completed dwelling. This stage was reached three weeks after the first blocks were laid. In the pair on the right the guide rails have been removed and the position of the solid concrete, which is filled in between them, can be seen. The rough-cast surface has now to be applied.

### ARCHITECTURAL TREATMENT.

So far we have been concerned with the method of construction which has been employed on this estate. The design and appearance of the cottages, however, are not altogether satisfactory, but this fact is not necessarily a reflection upon the system of construction. There are many brick-built houses that are entirely unsatisfactory considered as an architectural composition, but brick is not, therefore, condemned as a building material, and the faults which are so obvious in the houses on the Meanwood Estate are not dependent upon the material. There is, however, a very grave danger that the method of construction will be condemned by many on account of the appearance of the houses by those who are determined to seize upon any opportunity, however unjustifiable, to discredit

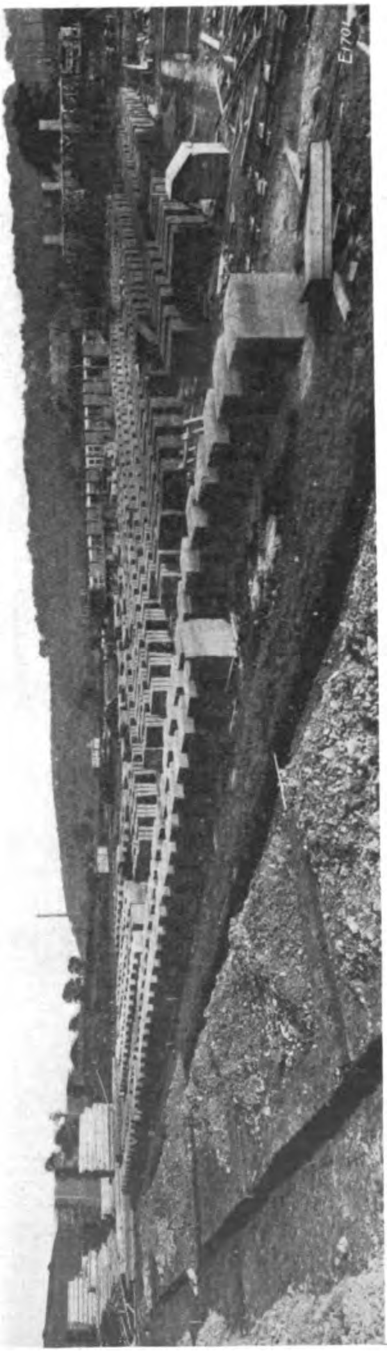


Fig. 2. Blocks stacked on the site.

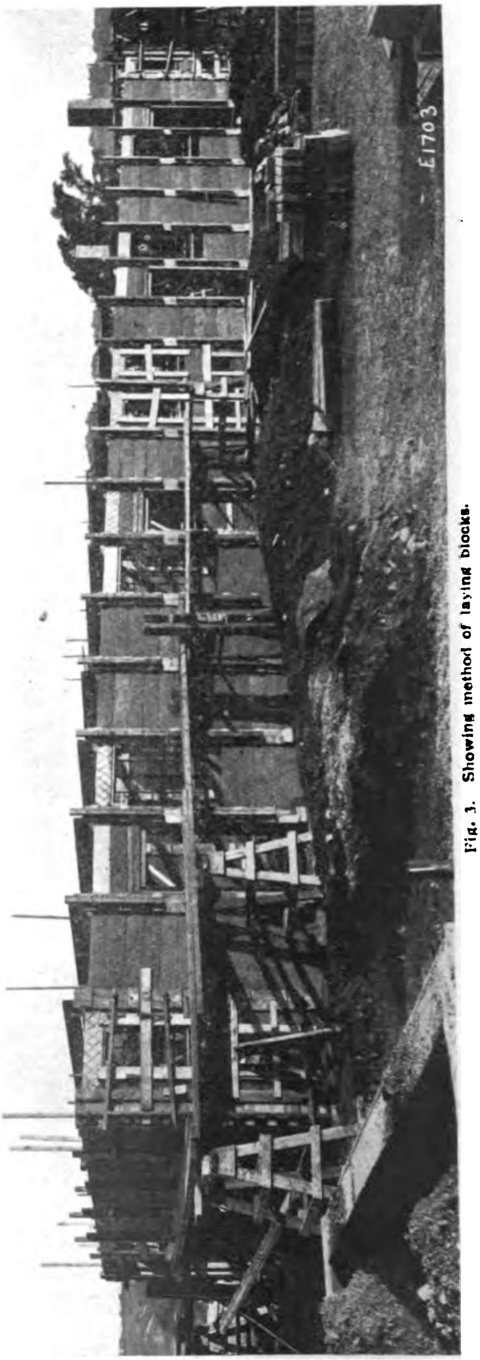


Fig. 3. Showing method of laying blocks.
Meanwood Housing Scheme.

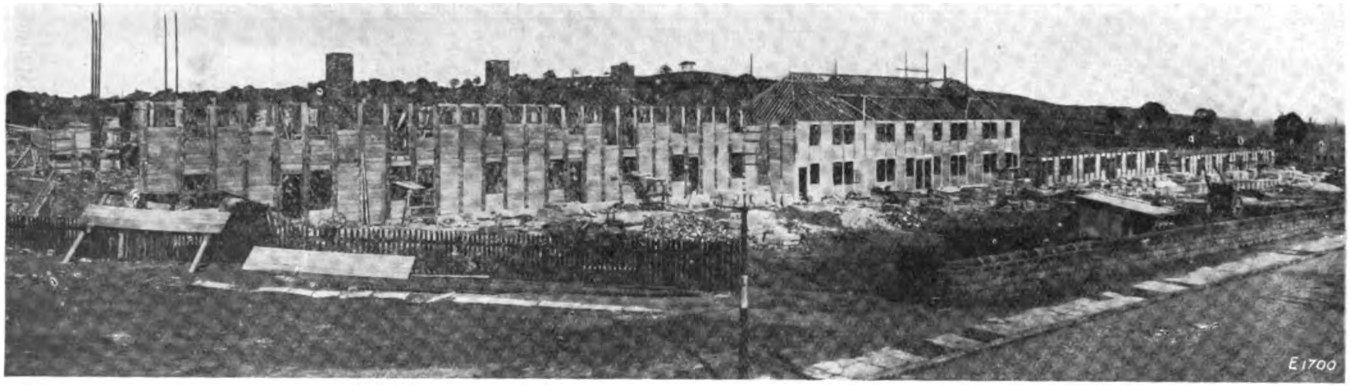


Fig. 4. Houses under construction.

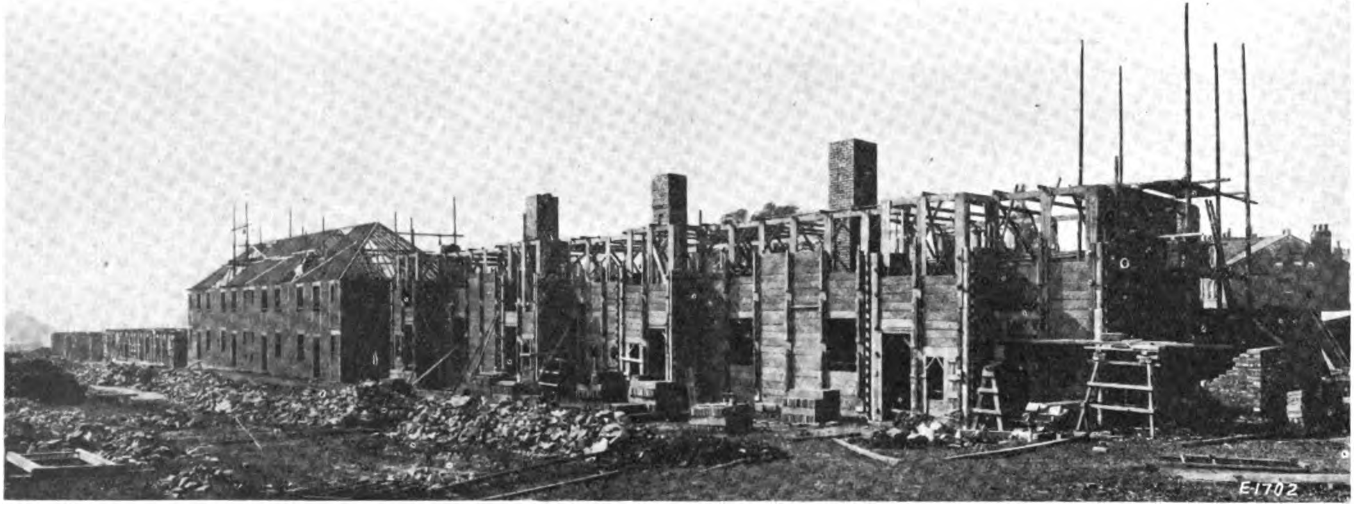


Fig. 5. Work proceeding on the upper storey.

MEANWOOD HOUSING SCHEME.

concrete. It must be conceded that an estate of 600 to 800 houses on the lines of the completed house shown in *Fig.* 6 does not suggest a pleasant prospect. Simple wall and roof surfaces can be conducive to the most charming results, and there are many prototypes of the late-eighteenth and early-nineteenth centuries which show the delights of such simple treatment. But they possess, in addition, certain features without which the houses are nothing more than slate-lidded boxes. The addition of a simple cornice, a pedimented hood over the doors, better-proportioned windows—which should be double-hung sashes and not casements—would infinitely have improved the appearance. A window should also have been placed over the door, and certain of the windows should be three-light—a large central with two narrower side sashes. The introduction of bay windows to the ground floors of certain of the types, and an occasional projecting feature in the centre and at the ends of the blocks, would have been desirable improvements both in plan and in elevation.

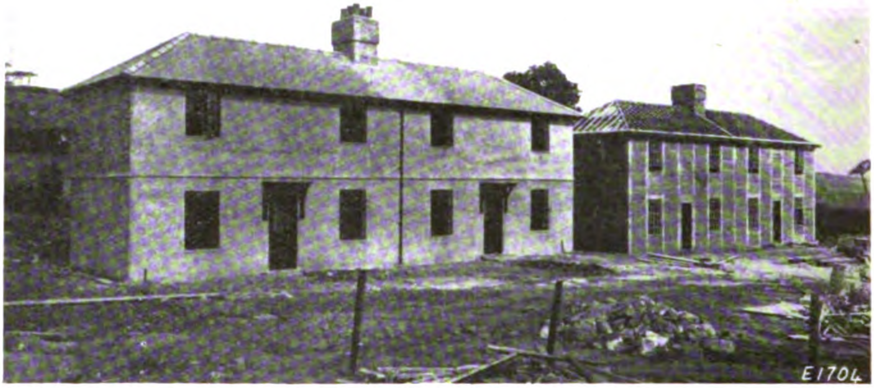


Fig. 6. Finished Houses.
MEANWOOD HOUSING SCHEME.

It is realised, in these days of high cost, that it is necessary ruthlessly to delete all that can possibly be considered as superfluous, and it may be that it is this policy that has led to this unsatisfactory result. Whatever may be the cause, it is certainly to be regretted.

## MEMORANDUM.

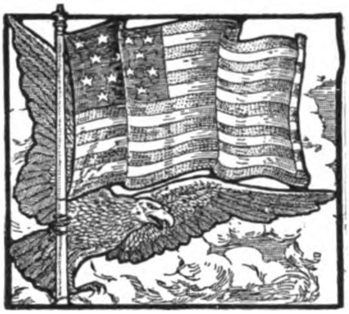
**Educational Lectures.**—We understand a course of lectures on Structural Engineering is in progress at the *Architectural Association*, 35, Bedford Square, taken by Dr. Oscar Faber, O.B.E. The subjects are :—

*Autumn Term* (now in progress) : General statics and strength of materials.

*Spring Term :* Steelwork.

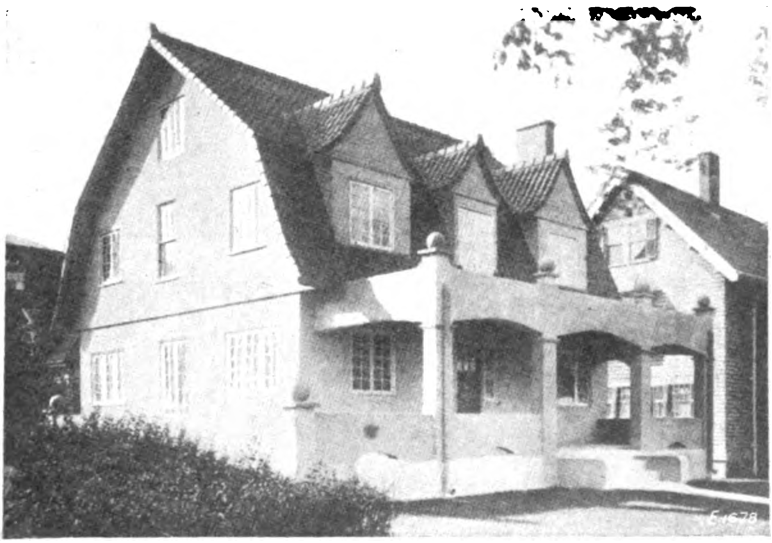
*Summer Term :* Reinforced Concrete Lectures, Thursdays, 5–6 p.m. ; Exercises 6–7 p.m.

A course of lectures is to be given on Reinforced Concrete by Dr. Oscar Faber, O.B.E., at *University College*, on Friday afternoons, especially for University students. The first lecture was given on October 29th. There will be one course for engineers, and a less advanced course for architects, and each lecture will be followed by exercises.



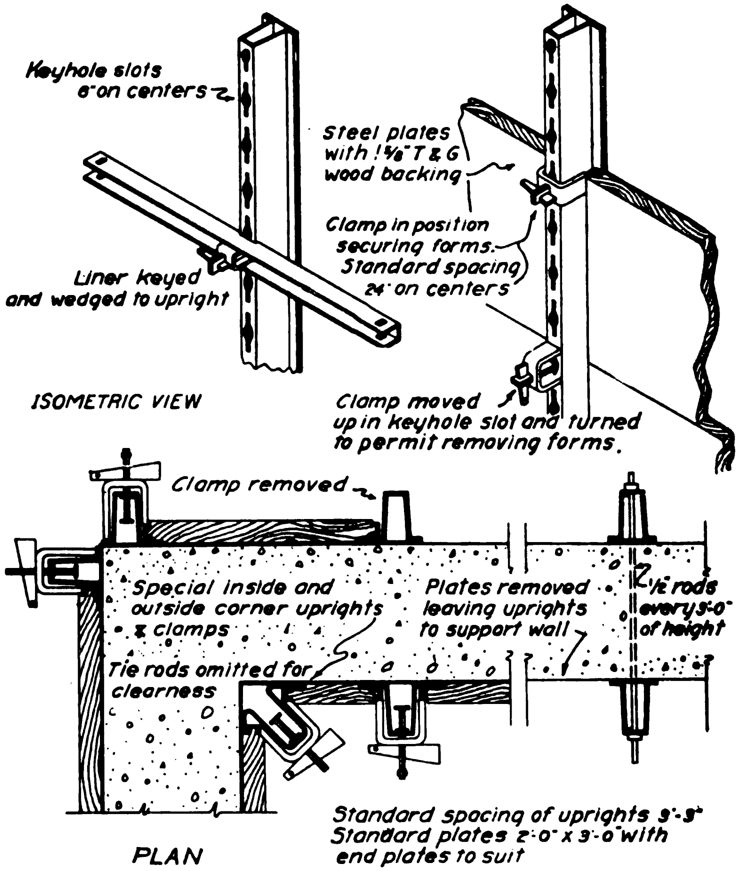
# PROCEEDINGS OF NATIONAL CONFERENCE ON CONCRETE HOUSE CONSTRUCTION IN THE UNITED STATES.

It has always been felt, in England, that the possibilities of the architectural use of concrete have been much more widely realised and exploited in America than in England. The perusal of the *Proceedings of the National Conference on Concrete House Construction* cannot but confirm and justify this belief. The very fact that such a conference has been convened testifies to the importance of the position, in national affairs, occupied by concrete house building. The conference, which met in February, 1920, at Chicago, was attended by representatives of some twenty-eight organisations. There is much in the published volumes of the proceedings of particular interest, but there is throughout a general interest in observing how another great country has attempted to solve the vast problem of housing shortage so similar in many respects to our own. And on this general question we, in England, have no reason to be ashamed or to disparage ourselves, for it would certainly appear that we have approached the matter in a more energetic and comprehensive manner. With regard, however, to the exploitation of concrete we have no ground to feel so self-satisfied.



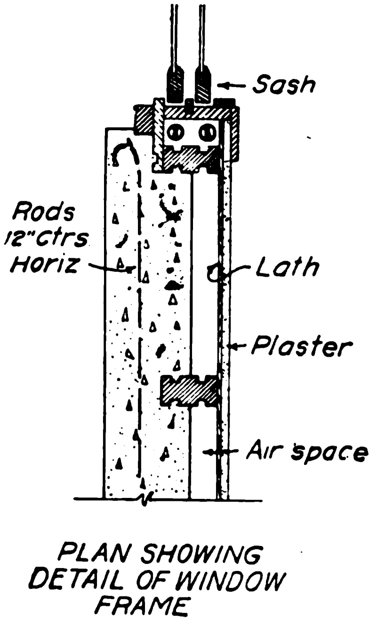
A Concrete Residence of Brooklyn, Mass.

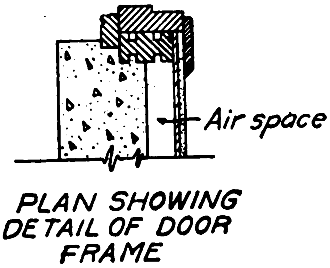
Not only do we, as yet, fail to realise the full structural possibilities of the material, but we have failed, still more, to appreciate the diversity of subsidiary uses about a building to which it may be put. It may, in fact, be used with advantage for many things now made exclusively of other materials. The question of the proper designing of cement products has also hitherto received insufficient attention. " Cement products cannot be successfully and truly sold until they are properly and intelligently designed," says Mr. Henry K. Holsman in an interesting paper on this subject.



HYDRAULIC STEELCRAFT SYSTEM.—DETAILS OF FORMS.

The question of the provision of farms is dealt with very fully, and although the prevalent conditions and customs demand a somewhat different arrangement to that usually provided in England, nevertheless the plans that are reproduced in the volume show how thoroughly the matter has been considered from the aspect of economy in construction and compact planning. Several papers and reports concern themselves with the question of housing finance, but the interest in this matter will not be very general. The report of the Committee on Fire Protection deals very fully with the inadequate safeguards prevailing in many districts, and shows how these may be overcome by a wider use of concrete. Building bye-laws, or codes as they are called in America, are the subject of a paper, and a suggestion is put forward that concrete block makers should be compelled to have a special building or enclosure for protection from cold and heat and inclement weather, in which the blocks shall be manufactured, and that licences shall be issued to all block makers. This seems hardly practicable, especially as it would remove one of the greatest advantages of concrete block work, which is the use of a machine on the site. The obstruction caused by





The Fellgren System.
General Details of Forms.

A Concrete House on the Moore System at Houston, Texas.

obsolete building codes, or by those which should only be applicable to brick or stone and not concrete, is touched upon

It is in the matter of concrete monolithic houses that America has far outdistanced England. The variety of design and the ingenuity of construction are surprising. Much inventive and latent energy has been applied to the production of forms that shall be capable of repeated use, but yet not necessarily entailing a repetition of design. The forms themselves must be adaptable. Many of the methods would seem to be extremely complex, but it must be remembered that this whole method of construction has been slowly evolved and perfected, and in the process it has produced the necessary trained operatives, while we as yet still stand on the threshold.

The Hydraulic Steelcraft forms are typical of many that are largely in use for this particular system of construction. These forms consist of light pressed U-shaped vertical liners and horizontal ribs supporting steel form plates backed with wood. The edges of the wood backing are clad with light steel plates. Keyhole slots in the backs of the vertical liners enable the horizontal ribs to be clamped on by means of a key, wedge and U-clamp. No part is too heavy to be moved by one man. It is interesting to observe the method by which the cavity—so essential to maintain an equable temperature—is constructed; it is placed between the solid concrete wall and an inside lining which is usually formed with some kind of expanded metal lathing and plaster.

Another branch along which development has taken place far more rapidly than in England, and which is discussed very fully in the report, is pre-cast construction. This system is best adapted to large groups of buildings or to large development schemes on town-planning lines where it is possible economically to instal adequate mechanical plant both for the manufacture and for the erection of the parts. This method of unit construction does not entail endless repetition, but depends upon designing to certain standardised structural members, which may be used for single or semi-detached houses or apartment dwellings. Where the size of the work justifies it, complicated plant is installed, and the process of manufacturing the units follows the general lines of modern industrial operations; the mixing of the concrete, its transportation to the forms, and the subsequent removal of the finished parts are all effected by mechanical means.

Yet a third line of development which has received still less consideration in England is the method known as gunite houses. This method is defined as follows: "The plastered or gunite concrete house is one having a reinforced concrete structural framework, either cast in place or shot with a cement gun and having comparatively thin exterior double walls of concrete formed by plastering or shooting concrete on expanded metal, or weak reinforcement." With this system the expense and complication of forms is entirely avoided, and it has complete adaptability.

The treatment of concrete surfaces has been very thoroughly considered in America, and, as the result of continual experiments with various aggregates a series of different effects are obtainable which far exceed anything attempted in England. Aggregate-exposing can be accomplished in a variety of ways, such as acid washing, water spraying, scrubbing, washing, tooling or rubbing. With certain aggregates, such as marble or granite, rubbing will impart to the surface a polish very similar to the natural stone. Building ornaments are extensively made in concrete. Sometimes the method of manufacture is by means of casting in moulds, at others the artist builds up his design with a permanent skeleton framework similar to when modelling in clay.

It is noticeable that in America, as in England, the architectural profession seems slow to realise the possibilities of concrete, and most of the experimental work has been carried out by engineers. It is surely time that all signs of apathy towards a material capable of such wide and diverse application were altogether discarded.

TRIMSTONE WORK.

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## MEMORANDUM

**Concrete Tile.**—A new form of concrete tile, known as the Wightman tile, is to be developed in the United States, a special machine and auxiliary equipment having been set up for it at Detroit. The basic unit to be manufactured is a thin-walled concrete tile 3¾ in. by 5⅜ in. by 12 in.; various multiples of this unit up to 5⅜ in. by 16⅞ in. by 12 in. are made, to lay up in even tiers with bricks.

The object of the inventors is to produce a lightweight unit giving a maximum of strength with a minimum of weight, so proportioned as to lend itself to the most elastic uses in wall construction.

Every effort has been made in establishing the plant for making the tiles to produce a large number of tiles with a minimum of manual labour, and it is said that with 16 men (comprising 10 operatives and 6 non-productive employees) an output of 30,000 to 36,000 basic concrete units can be turned out in a 10-hour working day.

These tiles are said to differ from ordinary concrete blocks in two respects: they are lighter, and are made to provide two or more load-supporting webs tied together with cross-webs and laid with core openings running horizontally, providing a top and bottom plate, and giving a full mortar bed area.

One tile unit represents 2 bricks high, 1 brick wide and 1½ bricks long, and would displace 3 bricks.

# THE CONCRETE INSTITUTE.

## MONTHLY NOTES.

By the SECRETARY

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### COMMITTEE MEETINGS FOR NOVEMBER AND DECEMBER.

(Thursdays except where otherwise noted.)

| | | |
|---|---|---|
| November | 4th | Reinforced Concrete Practice Standing Committee, at 4 p.m.<br>Science Standing Committee, at 5.30 p.m. |
| ,, | 11th | Literature Standing Committee, at 5.30 p.m. |
| ,, | 18th | Finance and General Purposes Committee, at 5.30 p.m. |
| ,, | 25th | Council Meeting, at 5.30 p.m. |
| ,, | | Ordinary General Meeting, at 7.30 p.m. PRESIDENTIAL ADDRESS by E. Fiander Etchells, A.M.Inst.C.E., etc. (Lantern.) |
| December | 2nd | R.C. Practice Standing Committee, at 4 p.m.<br>Science Standing Committee, at 5.30 p.m. |
| ,, | 8th | (Wednesday) Finance and General Purposes Committee, at 5.30 p.m. |
| ,, | 15th | (Wednesday) Literature Standing Committee, at 5.30 p.m. |
| ,, | 16th | Council, at 5.30 p.m<br>Ordinary General Meeting, at 7.30 p.m.<br>Paper by Mr. H. J. Deane, M.Inst.C.E., entitled "Special applications of Reinforced Concrete in Docks, with specific reference to the R.C. Gates at Tilbury Docks." (Lantern.) |

At the meeting of the Reinforced Concrete Practice Committee held in October it was decided to proceed with the preparation of a Standard Specification for the use of Concrete Blocks.

The Science Standing Committee, at its October meeting, agreed to extend its consideration of the subject of adhesion and friction so as to include "The coefficient of friction between concrete and other substances.'

### CONCRETE AGGREGATES (*continued*).*

SUPPLEMENTARY LIST.

(7*a*) **Beaconsfield (Buckinghamshire).**—(i) Sand containing 40 per cent. loam ; 94 per cent. passes a 50 sieve. (R.C.B.) ‡
(ii) Gravel and sand containing 20 per cent. loam. (R.C.B.)

(13*a*) **Brightlingsea (Essex).**—(i) Good sea gravel. (R.C.B.)
(ii) Pit gravel and sand. Very loamy. (R.C.B.)

As carried forward from August issue :

(15) **Cardiff.**—
*General description :* Limestone.
*Source and locality :* Quarries at Twynyvodyn, Tynant and Rhubina, Dinas Powis, near Cardiff.

*How obtained :* Quarrying.
*From whom obtained :* Osmond Brothers, Ely, near Cardiff; Walter E. Lewis, Dinas Powis; T. Edwards, Tynant, Taff's Well; John Llewellyn, Rhubina, near Cardiff.
*Is available quantity limited ?* No.
*Present maximum output per day :* †
*Transport facilities :* Road and rail.
*Is there any provision at or near source for washing or crushing ?* Yes (for crushing).
*Price per cubic yard, and where delivered :* Approximately 13s. 9d., delivered in Cardiff.
*Is composition uniform ?* Fairly.
*Kind of stone or coarse material :* Limestone.
*Kind of sand or fine material :* Limestone.
*Shape of particles :* Angular.
*Size of particles :* 2¼ in. and 1½ in.

(16) **Carmarthenshire.**—

| | (i) | (ii) |
|---|---|---|
| *General description :* | Limestone. | Crushed limestone. |
| *Source and locality :* | Quarries. | Coygen quarry. |
| *How obtained :* | † | Blasting and crushing. |
| *From whom obtained :* | Lime Firms, Ltd., Llandebie. | H. Raymond, Laugharne, St. Clears. |
| *Is available quantity limited ?* | No. | No. |
| *Present maximum output per day :* | † | Fifty tons. |
| *Transport facilities :* | Rail. | Road. |
| *Is there any provision at or near source for washing or crushing ?* | Crushing. | Yes. |
| *Price per cubic yard, and where delivered :* | 5s. 7d. per ton (*sic*) at works. | 5s. 8d. at works. |
| *Is composition uniform ?* | Yes. | Yes. |
| *Kind of stone or coarse material :* | Crushed as required | Welsh limestone. |
| *Kind of sand or fine material :* | | Chippings. |
| *Relative proportion of coarse and fine material :* | | Just enough to fill interstices. |
| *Shape of particles :* | | Angular. |
| *Size of particles :* | | All passed through ⅝ in. mesh. |
| *Impurities present :* | Clean. | None. |
| *General remarks :* | This material is quite good for aggregate. | Concrete made with Coygen chippings is as good as Thames ballast with only half the cement in it. |

(17) **Cheltenham (Gloucestershire).**—Northope sand; 45 per cent. passes a 50 sieve; 10 per cent. loam and chalky. (R.C.B.)

(18) **Chester.**—Fairly good local sand; sharp. Granite quarries not far distant, belonging to the Penmaenmawr and Welsh Granite Co. (*q.v.* later), the Ceiriog Granite Co. at Chirk and the Arenig Granite Co. at Shrewsbury.

(19) **Chorley (Lancashire).**—Sand, 43 per cent. loam (R.C.B.)

(20) **Clitheroe (Lancashire).**—Limestone; very flat. (R.C.B.)

(21) **Cookham R.D.C. (Berkshire).**—
*General description :* Gravel and Thames ballast.
*Source and locality :* River bed, Thames; and private gravel pits.

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* See issues of August and September, 1920.
† No information supplied.
‡ Items marked R.C.B. are from information kindly furnished by Mr. R. C. Branston and forwarded by the British P.C. Manufacturers, Limited.

*How obtained :* Dredged and dug gravel.
*From whom obtained :* Thames Conservancy and private owners.
*Is available quantity limited ?* No.
*Transport facilities :* Horse haulage and mechanical transport.
*Is there any provision at or near source for washing or crushing ?* No.
*Price per cubic yard :* 4s. 6d. for local gravel. £1 for washed ballast.
*Is composition uniform ?* Fairly.
*Kind of stone or coarse material :* Flint.
*Kind of sand or fine material :* Siliceous.
*Relative proportions of coarse and fine materials :* Vary (1 sand, 3 flint).
*Shape of particles :* Rounded (large particles) ; angular (small particles).
*Size of particles ; approximate percentage, that needs crushing to pass ¾ in. screen :* 3 in. to 4 in. ; 50 per cent.
*Impurities present :* Chalk, clay.
*Source of information :* A. R. Heritage, 1, Park Street, Maidenhead.
*General remarks :* Very much used locally ; very small percentage, if any, delivered by barge or rail.

### NOTICE TO MAKERS OF CONCRETE SEWERS AND CONCRETE DRAIN PIPES.

Makers of concrete sewers and makers of concrete drain pipes are requested to send particulars of their products to the Secretary of the Concrete Institute.

The particulars should include the minimum and maximum diameters, the maximum lengths, and information as to the nature of joints and connections. These particulars are required for co-ordination, tabulation, and circulation to our members.

### NOTICE TO MAKERS OF CONCRETE INSPECTION CHAMBERS.

Makers of reinforced concrete sectional inspection chambers and other similar plant are also requested to send particulars of their products to the Secretary of the Concrete Institute for the purposes outlined above.

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## MEMORANDUM.

**Concrete Work in Winter.**—In the construction of a large reinforced concrete factory building at Montreal last year some ingenious methods were used in order that the work might proceed during the winter months. As a result, the greater part of the work was carried out from November to March, and hardly a day was lost through cold or frost. The bulk of the concrete was poured by means of two spouting chutes on wooden towers. Hot water was used for mixing the concrete, and the sand and stone aggregate were heated by steam pipes running through the piles. Tarpaulins were used in the usual manner to protect the exterior, and salamanders (a form of asbestos or mineral flax) were placed under the floor slabs. When the concrete was partially set it was thickly covered with sawdust.

An interesting constructional feature is that the foundation walls, 24 in. thick, have no footings, but span from column footing to column footing.

# EFFECT OF FINENESS OF CEMENT.*

**By DUFF A. ABRAMS, Professor in Charge of Laboratory.**

*Below we give some extracts and illustrations from the Bulletin commented upon in our Editorial Notes on p. 723. The Report is that published by the Structural Materials Research Laboratory, Lewis Institute, Chicago.—ED.*

## SUMMARY.

THE recent revision of the Standard Specifications for Portland Cement served to focus the attention of engineers on the function of fineness of grinding of cement in producing concrete of high strength and other desirable properties. An investigation of this subject has been under way at Lewis Institute for the past four years. Five series of tests have been completed; another series, now under way, is not included in this report. These studies were made as a part of the investigations of concrete and concrete materials being carried out through the co-operation of the Portland Cement Association and Lewis Institute at the Structural Materials Research Laboratory.

The Portland cements used were from seven commercial mills. These plants represent the principal cement-producing districts east of the Mississippi River. Fifty-one different samples of cement were used. The cements were ground at the mill to four to seven degrees of fineness, which gave residues ranging from 2 to 43 per cent. on the standard No. 200 sieve. In general, the aggregate consisted of sand and pebbles; in one series blast-furnace slag and a light-weight aggregate consisting of burnt shale were used.

This report covers compression tests on 6,125 6 in. by 12 in. concrete cylinders, 9,000 compression and tension tests of mortar, and several thousand miscellaneous tests. Strength tests of concrete and mortar were made at ages of seven days to one year.

Definite information has been secured on the effect of fineness of cement under the following conditions:

(*a*) Effect of fineness of cement on the strength of concrete;
(*b*) Quality of concrete using different cements;
(*c*) Effect of the quantity of cement used;
(*d*) Effect of consistency of the concrete;
(*e*) Effect of size and grading of the aggregate;
(*f*) Variation in the type of aggregate;
(*g*) Effect of age of concrete;
(*h*) Elongation and contraction of concrete;
(*i*) Effect of fineness of cement on workability of concrete.

The following may be stated as the principal conclusions from the tests:

1. There is no necessary relation between the strength of concrete and the fineness of the cement, if different cements are considered.

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* Authorised reprint from the *Proceedings* of the American Society for Testing Materials, Vol. XIX., Part II., 1919. The oral and written discussions of this paper which appear in the *Proceedings* are not reprinted.

2. In general, the strength of concrete increases with the fineness of a given lot of cement, for all mixes, consistencies, gradings of the aggregate, and ages of concrete. The cements with residues lower than about 10 per cent. were inclined to give erratic results in the strength tests; one lot showed an abnormal increase, and two others a pronounced decrease in strength as compared with the other tests on coarser cements in the same lot.

3. For residues higher than 10 per cent. the strength of concrete varies approximately inversely as the residue on the No. 200 sieve.

4. Fine grinding of cement is more effective in increasing the strength of lean mixtures than rich ones.

5. Fine grinding of cement is more effective in increasing the strength of concrete at seven days than at ages of twenty-eight days to one year.

6. For the usual range of consistencies the effect of fineness of cement is independent of the consistency of the concrete. The rate of increase in strength with fineness is lowered for very wet mixtures.

7. Ordinary concrete mixtures at twenty-eight days show an increase in strength of about 2 per cent. for 1 per cent. reduction in the residue of the cement on the No. 200 sieve. At seven days, three months, and one year the corresponding increases in strength are about 2·5, 1·7, and 1·4 per cent.

8. The decreased benefit of fine grinding of cement with the age of the concrete does not bear out accepted opinion that the coarser particles of cement do not hydrate, but indicates that the principal result of finer grinding is to hasten the early hardening of the concrete.

9. For the richer mixtures and the consistency necessary for building construction, the fineness of the cement has no appreciable effect on the workability of concrete as determined by the " slump " test. For leaner mixtures and wetter consistencies the finer cements showed a somewhat greater " slump " than the coarser cements.

10. The normal consistency of cement is increased with fineness of grinding. About 0·1 per cent. of water (in terms of the weight of the cement) must be added for each 1 per cent. reduction in residue on the No. 200 sieve.

11. The time of setting of the cement is shortened with finer grinding. In some instances initial setting time with the Vicat needle was shortened to five to ten minutes.

12. The unit weight of cement decreases with fineness. For the cements used in these tests the weight varied from 76 (residue of 2·4 per cent.) to 108 lb. per cu. ft. (residue 43·3 per cent.). For the usual range in fineness the weight is lowered about ¾ lb. per cu. ft. for each 1 per cent. reduction in the residue on the No. 200 sieve.

13. In using 94 lb. per cu. ft. as a uniform basis for proportioning the cements in these tests, the actual volume of cement in a batch *of the same mix* varies about 35 per cent. If the mixtures had been proportioned in a manner that would have given a uniform *volume* of cement, the resulting concrete strength would not have been so favourable to the finer cements.

14. The fineness of cement has no appreciable effect on the yield or density of concrete.

15. Concrete of all mixes and consistencies showed expansion in damp sand or water storage and contraction in air.

16. The change in length of concrete specimens stored in air or water is independent of the fineness of the cement and the consistency of the concrete. The lean concretes are slightly less affected than the rich mixtures.

17. The type of aggregate has little or no influence on the relative effect of fineness of cement on the strength of concrete.

18. The tests included in this report show an intimate relation between the strength of the concrete and the water-ratio of the mixture. The lower the water-ratio (so long as the concrete is plastic and the aggregate not too coarse) the higher the strength, and *vice versa*. This confirms the results of other concrete tests made in this laboratory. Increasing the quantity of cement in a given mixture enables us to secure a concrete of equal workability with a lower water-ratio, hence a higher strength.

19. In ordinary concrete mixtures (say, 1 : 5 to 1 : 4, requiring 20 to 25 per cent. cement, by volume) increasing the cement content by 1 per cent. (to 20·2 per cent. for a 1 : 5 mix) gives an increase in strength of about 1 per cent.

### TABLE I.—OUTLINES OF TESTS—SERIES 20, 31 AND 60.

**Tension tests of briquettes and compression tests of 2 by 4-in. and 6 by 12-in. cylinders.**
**Mortar specimens mixed 5 in a batch, 1 for each age.**
**Concrete specimens proportioned and mixed in separate batches.**
**Mortar specimens stored in water; tested damp.**
**Concrete specimens stored in damp sand; tested damp.**
**Normal consistency mixtures.**

| Fineness of Cement Residue on No. 200 Sieve. | Form of Specimen. | Mix. | Aggregate. | | | Age at Test. | Specimens in a Set. | Number of Specimens. |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Size. | F. M. | | | |
| | | | | SERIES 20. | | | | |
| A B C D E<br>12.5 12.1 16.1 16.1 10.6<br>16.9 16.5 20.6 20.3 15.3<br>19.9 20.4 26.5 22.3 18.9<br>22.9 23.0 33.3 25.6 23.7 | Briquettes<br>2 by 4-in. Cylinders. | Neat[1]<br>1:2<br>1:3<br>1:4 | Standard sand<br>Elgin sand | No. 20-30<br>0-No. 4 | 2.67<br>3.00 | 7 d.<br>28 d.<br>3 mo.<br>6 mo.<br>1 yr. | 4 | 3900 |
| | 6 by 12-in. Cylinders. | 1:2:4<br>1:3:5 | Elgin sand and pebbles | 0-1½ in. | 5.60<br>5.43 | | | 600 |
| | | | | SERIES 31. | | | | |
| F G H<br>4.9 2.2 12.0<br>8.7 7.9 19.9<br>14.2 12.9 23.3<br>17.9 19.9 25.1<br>24.5 25.2 30.1<br>28.1 29.6 ....<br>33.4 34.0 .... | Briquettes<br>2 by 4-in. Cylinders. | Neat[1]<br>1:3 | Standard sand<br>Elgin sand | No. 20-30<br>0-No. 4 | 2.67<br>3.00 | 7 d.<br>28 d.<br>3 mo.<br>6 mo.<br>1 yr. | 4 | 2650 |
| | 6 by 12-in. Cylinders. | 1:1½:3<br>1:1¾:3½<br>1:2:4<br>1:2½:5<br>1:3:6 | Elgin sand and pebbles | 0-1½ in. | 5.53 | | | 2375 |
| | | | | SERIES 60. | | | | |
| F<br>4.9<br>8.7<br>14.2<br>17.9<br>24.5<br>28.1<br>33.4 | 2 by 4-in. Cylinders. | 1:2.55 Elgin sand by volume. | | 0-No. 4<br>0-No. 4<br>0-No. 4<br>0-No. 4<br>0-No. 8<br>0-No. 4 | 4.44<br>4.06<br>3.63<br>3.17<br>3.00<br>2.53 | 7 d.<br>28 d.<br>3 mo.<br>6 mo.<br>1 yr. | 5 | 1050 |

[1] Briquettes only.

20. One per cent. increase in cement is more effective in increasing the strength of concrete in lean than in rich mixtures.

21. One per cent. increase in cement is somewhat more effective in increasing the early strength of concrete than at later periods.

22. The effect of increasing the quantity of cement is independent of the consistency of the concrete.

23. Tension tests of briquettes do not give a correct measure of the relative merits of different cements as determined by compression tests of mortar and concrete.

OUTLINES OF TEST SERIES.

Skeleton outlines of the tests of each of the series (Tables I. to III.) give the principal characteristics of the cements and indicate the variations in mix, consistency, size and grading of aggregate, etc. The series numbers furnish a convenient method of reference in identifying tests.

Series 20 was begun in August, 1915. Five different cements were used, each ground to four different degrees of fineness varying from about 10 to 33 per cent. residue on the No. 200 sieve. Two concrete mixtures were used and three mortar mixtures. Tests were made at ages of seven days to one year.

**TABLE II.—OUTLINE OF TESTS—SERIES 118.**

**Compression tests of 6 by 12-in. concrete cylinders. Hand-mixed concrete.**
**Concrete for each cylinder proportioned and mixed in a separate batch.**
**Plasticity determined by the "slump" method.**
**Five tests in a set made on different days.**
**Stored in damp sand; tested at 28 days.**
**Cement I-1, same as that used in concrete ship "Atlantus."**
**Cement I-2, standard mill product purchased from local contractor, Brunswick, Ga.**
**Cements K and L, different brands ground to 5 degrees of fineness.**

| Ref. No. | Cement. | | Mix by Volume. | Relative Consistency. | Aggregate. | | Number of Tests. |
|---|---|---|---|---|---|---|---|
| | Fineness, Residue on No. 200 Sieve.[1] | Normal Consistency. | | | Kind. | Grading | |
| I-1.... | 8.9 | 23.5 | 1:1⅞ | 0.90<br>1.00<br>1.05<br>1.10<br>1.15<br>1.20<br>1.25<br>1.50 | Shale slag, sand and celite (*Same aggregate* and proportions as in concrete ship "Atlantus.") | 0–⅜ in. | 48 |
| I-2.... | 13.9 | 22.8 | | | | | |
| K-1... | 2.4 | 25.0 | 1:4 | 0.95<br>1.00<br>1.05<br>1.10<br>1.15<br>1.20<br>1.25<br>1.50<br>2.00 | Elgin sand and pebbles. | 0–¾ in. | 225 |
| K-2... | 9.4 | 23.4 | | | | | |
| K-3... | 17.7 | 23.0 | | | | | |
| K-4... | 27.9 | 22.8 | | | | | |
| K-5... | 36 2 | 22.2 | | | | | |
| K-1 .. | 2.4 | 25.0 | 1:1⅞ | 0 95<br>1.00<br>1.05<br>1.10<br>1.15<br>1.20<br>1.25<br>1.50<br>2.00 | Crushed blast-furnace slag, sand and celite. (Grading of aggregate and mix, same as in concrete ship. "Atlantus.") | 0–⅜ in. | 360 |
| K-2... | 9.4 | 23.4 | | | | | |
| K-3... | 17.7 | 23.0 | | | | | |
| K-4... | 27 9 | 22.8 | | | | | |
| K-5... | 36.2 | 22.2 | | | | | |
| L-1... | 7.1 | 23.4 | | | | | |
| L-2... | 16.3 | 22.9 | | | | | |
| L-3... | 28.9 | 21.8 | | | | | |
| L-4... | 32.3 | 21.4 | | | | | |
| L-5... | 43.3 | 20.0 | | | | | |

[1] Values for cement K are the average of 15 to 18 tests; cement L, 5 to 7 tests, and for cement I, 3 tests In these tests 3 to 5 different standard sieves were used.

Series 31, an outgrowth of the tests in Series 20, was begun March, 1916. It was felt that a sufficient number of finenesses was not used in Series 20, consequently in Series 31 two cements were ground to seven different degrees of fineness, and one to five degrees; the fineness varied from about 2 to 34 per cent. residue. In this series greater emphasis was placed on the concrete than on the mortar tests. Five different concrete mixtures were used and two mortar mixtures. Tests were made for all conditions at ages of seven days to one year.

Series 60 (October, 1916) was outlined for the purpose of determining the effect of fineness of cement on the strength of mortars made of sands of different grading. Six different gradings were made up using sand from Elgin, Ill., each graded to No. 4 sieve. Compression tests were made on 2 in. by 4 in. cylinders using Cement F from Series 31, ground to seven different degrees of fineness.

Series 118 (November, 1918) was carried out primarily for the purpose of studying the effect of fineness of cement using concretes of rich mixtures and different consistencies. Two of the cements were ground to five degrees of fineness. For the third cement (I) only two degrees of fineness were available. Cements I differed from the others in that they were not prepared from the same lot of clinker. Cement I-1 was used in the reinforced concrete ship *Atlantus* constructed at Brunswick, Ga. The samples were furnished by the U.S. Shipping Board for use in these tests. I-2 was the commercial product of the same brand, purchased from a contractor in Brunswick. In this series the aggregate was of small size, the purpose being to use the same

TABLE III.—OUTLINE OF TESTS—SERIES 120.

Compression tests of 6 by 12-in. concrete cylinders. Hand-mixed concrete.
Concrete for each cylinder proportioned and mixed in a separate batch.
Cements ground at the mill to 5 different degrees of fineness.
Aggregate, sand and pebbles from the Elgin, Ill., pit of the Chicago Gravel Co.
Plasticity measured by the "slump" method.
Stored in damp sand; tested damp.
Cylinders in a set mixed on different days.

| Ref. No. | Cement. | | Mix by Volume. | Size of Aggregate. | Relative Consistency. | Age at Test. | Cylinders in Set. | Total Cylinders. |
|---|---|---|---|---|---|---|---|---|
| | Fineness, Residue on No. 200 Sieve.[1] | Normal Consistency. | | | | | | |
| K-1...<br>K-2...<br>K-3...<br>K-4...<br>K-5... | 2.4<br>9.4<br>17.7<br>27.9<br>36.2 | 25.0<br>23.4<br>23.0<br>22.8<br>22.2 | 1:10<br>1:7<br>1:5<br>1:4<br>1:3<br>1:2 | 0-1½ in. | 0.90<br>1.00<br>1.10<br>1.25<br>1.50<br>2.00 | 28 d. | 6* | 1080 |
| K-1...<br>K-2...<br>K-3...<br>K-4...<br>K-5... | 2.4<br>9.4<br>17.7<br>27.9<br>36.2 | 25.0<br>23.4<br>23.0<br>22.8<br>22.2 | 1:4 | 0-1½ in. | 0.90<br>1.00<br>1.10<br>1.25<br>1.50<br>2.00 | 7 d.<br>3 mo.<br>1 yr. | 5 | 450 |
| K-1...<br>K-2...<br>K-3...<br>K-4...<br>K-5... | 2.4<br>9.4<br>17.7<br>27.9<br>36.2 | 25.0<br>23.4<br>23.0<br>22.8<br>22.2 | 1:4 | 0-No. 28<br>0-No. 14<br>0-No. 8<br>0-No. 4<br>0- ⅜ in.<br>0- ¾ "<br>0-1½ " | 1.10 | 7 d.<br>28 d.<br>3 mo.<br>1 yr. | 5 | 700 |
| K-1...<br>K-2...<br>K-3...<br>K-4...<br>K-5... | 2.4<br>9.4<br>17.7<br>27.9<br>36.2 | 25.0<br>23.4<br>23.0<br>23.8<br>22.2 | 1:4 | 0-No. 28<br>0-No. 14<br>0-No. 8<br>0-No. 4<br>0- ⅜ in.<br>0- ¾ "<br>0-1½ " | 1.10 | Elongation and Contraction tests only | 1 | 3/ |
| L-1...<br>L-2...<br>L-3...<br>L-4...<br>L-5... | 7.1<br>16.3<br>28.9<br>32.3<br>43.3 | 23.4<br>22.9<br>21.8<br>21.4<br>20.0 | 1:10<br>1:7<br>1:5<br>1:4<br>1:3<br>1:2 | 0-1½ in. | 0.90<br>1.00<br>1.10<br>1.25<br>1.50<br>2.00 | 28 d. | 3 | 540 |

[1] Values for cement K are the average of 15 to 18 tests; for cement L, 5 to 7 tests. In these tests 3 to 5 different standard sieves were used.

* Measurements of elongation and contraction only, on one round.

mixture and aggregate of the size employed in reinforced concrete ship construction. The burnt shale aggregates were the same as that used in the ship *Atlantus.* The coarse aggregate in this case consisted of burnt shale which after crushing was graded

**TABLE VII.—MISCELLANEOUS TESTS OF AGGREGATES.**

| Material. | Size. | Weight, lb. per cu. ft. | Density. | Sieve Analysis. (Per cent Coarser than Each Sieve.) | | | | | | | | | Fineness Modulus.[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 100 | 48 | 28 | 14 | 8 | 4 | ⅜ in. | ¾ in. | 1½ in. | |
| **SERIES 20.** | | | | | | | | | | | | | |
| Elgin sand | 0–No. 4 | 108 | 0 646 | 98 | 90 | 68 | 47 | 24 | 0 | .. | .. | .. | 3.27 |
| Elgin pebbles | No. 4–1½ in. | 102 | 0 612 | 100 | 100 | 100 | 100 | 100 | 98 | 70 | 7 | 0 | 6.75 |
| Elgin sand and pebbles (1:2:4 mix) | 0–1½ " | ... | ... | 99 | 97 | 90 | 82 | 75 | 65 | 47 | 5 | 0 | 5.60 |
| Elgin sand and pebbles (1:3:5 mix` | 0–1½ " | ... | ... | 99 | 96 | 88 | 80 | 72 | 61 | 43 | 4 | 0 | 5.43 |
| **SERIES 31.** | | | | | | | | | | | | | |
| Elgin sand | 0–No. 4 | 106 | 0.636 | 99 | 90 | 61 | 35 | 16 | 0 | .. | .. | .. | 3.01 |
| Elgin pebbles | No. 4–1½ in. | 104 | 0.623 | 100 | 100 | 100 | 100 | 100 | 100 | 60 | 20 | 0 | 6.80 |
| Elgin sand and pebbles | 0–1½ " | ... | ..... | 99 | 97 | 87 | 78 | 72 | 67 | 40 | 13 | 0 | 5.53 |
| **SERIES 60.** | | | | | | | | | | | | | |
| Elgin sand N-14 | 0–No. 4 | 109 | 0.652 | 100 | 98 | 95 | 86 | 65 | 0 | .. | .. | .. | 4.44 |
| " " N-10 | 0–No. 4 | 112 | 0.670 | 99 | 94 | 88 | 75 | 50 | 0 | .. | .. | .. | 4.06 |
| " " N-7 | 0–No. 4 | 116 | 0.694 | 99 | 86 | 77 | 63 | 38 | 0 | .. | .. | .. | 3.63 |
| " " N-5 | 0–No. 4 | 119 | 0.713 | 97 | 75 | 65 | 50 | 30 | 0 | .. | .. | .. | 3.17 |
| " " N-8 | 0–No. 8 | 107 | 0.640 | 100 | 100 | 67 | 33 | 0 | .. | .. | .. | .. | 3.00 |
| " " N-3 | 0–No. 4 | 116 | 0.698 | 96 | 57 | 47 | 35 | 18 | 0 | .. | .. | .. | 2.53 |
| **SERIES 118.** | | | | | | | | | | | | | |
| Brunswick sand | 0–No. 14 | 96 | 0.577 | 99 | 79 | 11 | 0 | .. | .. | .. | .. | .. | 1.89 |
| Burnt shale slag | 0–⅜ in. | 77 | 0.610 | 79 | 70 | 58 | 43 | 22 | 1 | 0 | .. | ... | 2.73 |
| Burnt shale slag | No. 8–¾ " | 53 | 0.522 | 100 | 100 | 100 | 100 | 100 | 85 | 11 | 0 | .. | 5.96 |
| Celite | ......... | 12 | 0.100 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .... |
| Mix of sand and shale slag[2] | 0–¾ in. | 73 | 0.618 | 92 | 86 | 74 | 67 | 59 | 38 | 5 | 0 | .. | 4.70 |
| Fine Elgin sand | 0–No. 14 | 109 | 0.655 | 89 | 50 | 13 | 5 | 1 | 0 | .. | .. | .. | 1.58 |
| Elgin sand | 0–No. 4 | 115 | 0.688 | 99 | 93 | 58 | 37 | 20 | 2 | 0 | .. | .. | 3.10 |
| Elgin pebbles | No. 4–¾ in. | 105 | 0.629 | 100 | 100 | 100 | 100 | 100 | 100 | 67 | 0 | .. | 6.67 |
| Elgin pebbles | No. 4–⅜ " | 105 | 0.629 | 100 | 100 | 100 | 100 | 100 | 100 | 0 | .. | .. | 6.00 |
| Slag | 0–No. 4 | 100 | 0.666 | 94 | 89 | 80 | 63 | 40 | 0 | .. | .. | .. | 3.66 |
| Slag | No. 4–⅜ in. | 90 | 0.599 | 100 | 100 | 100 | 100 | 100 | 100 | 0 | .. | .. | 6.00 |
| Mix of sand and shale slag[2] | 0–⅜ " | 108 | 0.721 | 96 | 92 | 85 | 78 | 67 | 51 | 0 | .. | .. | 4.70 |
| Elgin sand and pebbles | 0–⅜ " | 121 | 0.725 | 98 | 95 | 72 | 57 | 45 | 33 | 0 | .. | .. | 4.00 |
| Elgin sand and pebbles | 0–¾ " | 127 | 0.762 | 99 | 97 | 80 | 71 | 63 | 54 | 36 | 0 | .. | 5.00 |
| **SERIES 120.** | | | | | | | | | | | | | |
| Elgin sand | 0–No. 28 | 105 | 0 629 | 90 | 50 | 0 | .. | .. | .. | .. | .. | .. | 1.40 |
| " sand | 0–No. 14 | 107 | 0 641 | 96 | 87 | 31 | 0 | .. | .. | .. | .. | .. | 2.14 |
| " sand | 0–No. 8 | 109 | 0 653 | 99 | 89 | 45 | 17 | 0 | .. | .. | .. | .. | 2.50 |
| " sand | 0–No. 4 | 115 | 0 688 | 99 | 91 | 59 | 36 | 20 | 0 | .. | .. | .. | 3.05 |
| " sand and pebbles | 0–⅜ in. | 119 | 0 712 | 99 | 94 | 72 | 56 | 46 | 32 | 0 | .. | .. | 4.00 |
| " sand and pebbles | 0–¾ " | 126 | 0 754 | 99 | 96 | 81 | 71 | 63 | 54 | 36 | 0 | .. | 5.00 |
| " sand and pebbles | 0–1½" | 128 | 0.767 | 99 | 98 | 87 | 81 | 75 | 68 | 50 | 17 | 0 | 5.75 |

[1] The sum of percentages in the Sieve Analysis, divided by 100.

[2] Made up of 0.15 volumes of fine sand, 0.65 volumes of fine slag and 1.2 volumes of medium slag.

in size up to about ⅜ in. Small quantities of " celite " and fine sand were also used in the mixture. In another group in this series the mixtures and grading of aggregate were the same as those described above, except that blast-furnace slag was substituted

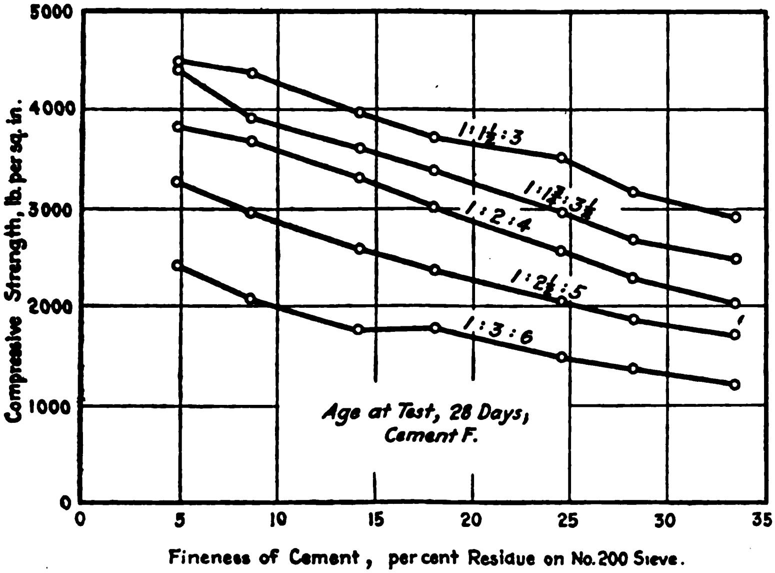


Fig. 8. Effect of Fineness of Cement on the Strength of Concrete—Series 31.

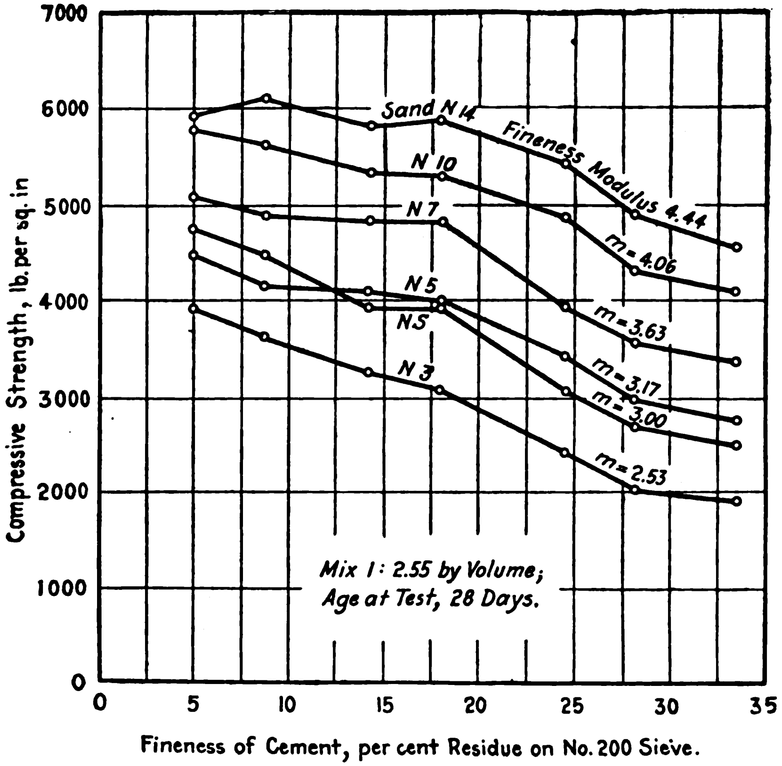
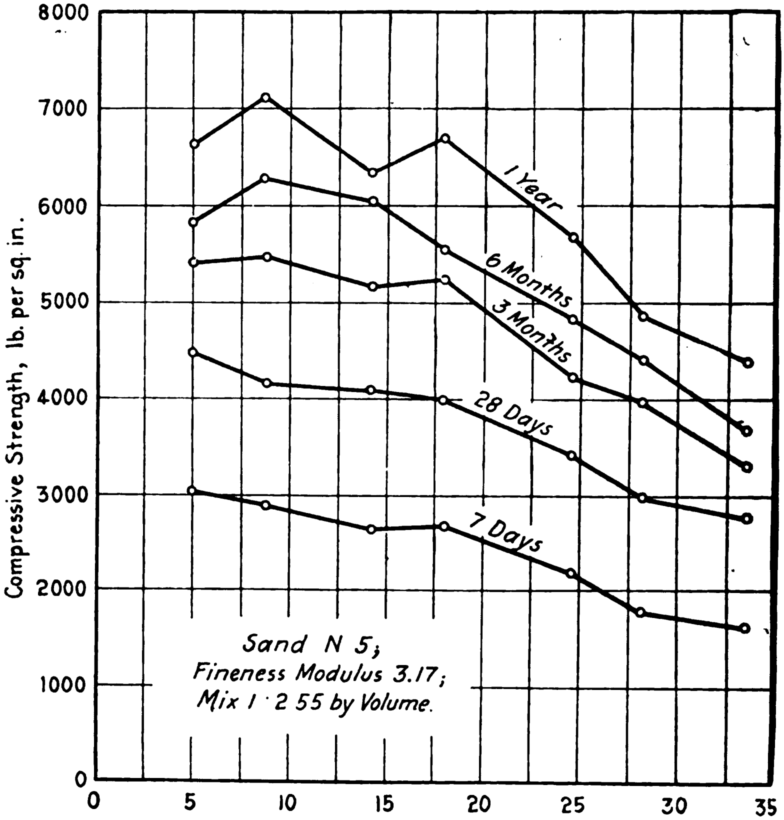
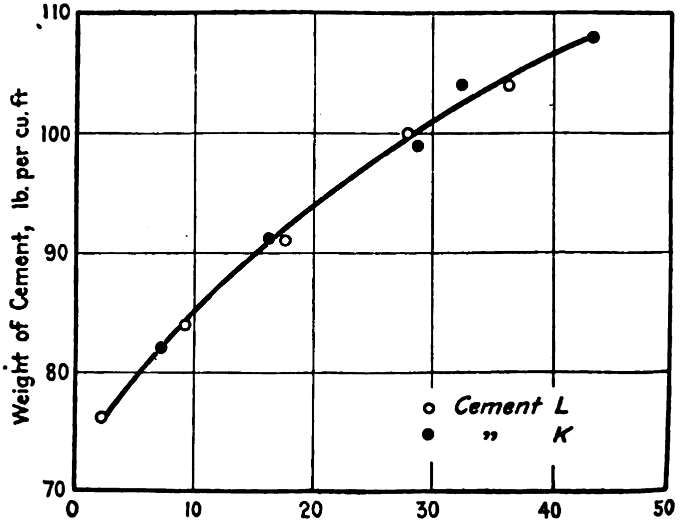


Fig. 16. Effect of Fineness of Cement on the Strength of Mortar—Series 60.



Fineness of Cement, per cent. Residue on No. 200 Sieve.

FIG. 17.—EFFECT OF FINENESS OF CEMENT ON THE STRENGTH OF MORTAR—SERIES 60. Compression tests of 2 by 4-in. cylinders. Curves platted for Sand N-5 only.



Fineness of Cement, per cent. Residue on No. 200 Sieve.

FIG. 20. EFFECT OF FINENESS ON UNIT WEIGHT OF CEMENT—SERIES 118. Values are based on 5 to 18 tests for fineness and 2 tests for unit weights.

for burnt shale. In the third group a 1 : 4 mix was used with sand and pebbles from Elgin, Ill. All tests were made at the age of twenty-eight days.

Series 120 (begun December 1918) was carried out with two cements, each ground at the mill to five finenesses varying from 2 to 43 per cent. residue. The principal feature of the tests was a study of the effect of fineness for a wide range of mixtures, consistencies, size, and grading of aggregates, and age of concrete. In two groups of tests measurements of elongation and contraction were made on 6 in. by 12 in. cylinders stored in damp sand, air and water. One-year tests in this series are not due.

After outlining the test series the materials used are fully described in the report, and illustrations and diagrams given ; Table VII. gathers up the details regarding the general tests concerning aggregate. In cases where different sizes of Elgin sand were used, the material was obtained by screening out the coarse sizes from the commercial product.

Dealing with the effect of fineness of cement on the strength of the concrete, a number of tables and diagrams are given which indicate generally that the strength of concrete increases with the fineness of cement. There are notable exceptions to this rule in the case of some of the cements having residues less than about 10 per cent. on the No. 200 sieve.

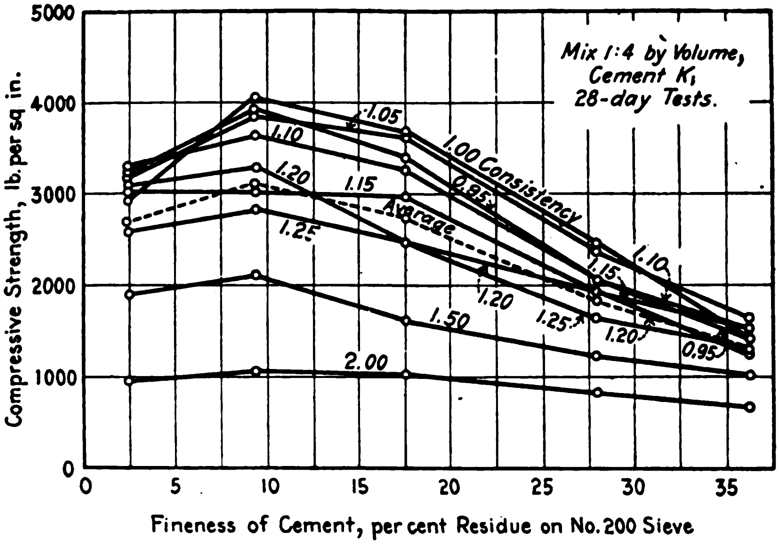


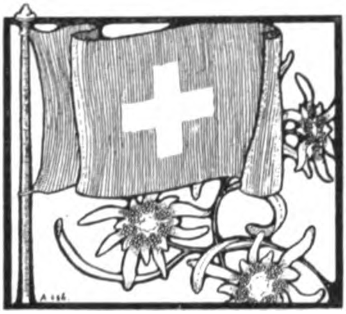
FIG. 21. EFFECT OF FINENESS OF CEMENT ON THE STRENGTH OF CONCRETE—SERIES 118.
Compression tests of 6–12-in. cylinders Cement K.
Aggregate: Sand and pebbles from Elgin, Ill., graded 0–¾ in.

The rate of change of strength of concrete with the fineness of the cement may be studied in several ways. One method is illustrated in *Fig.* 8, where the strength of the concrete for different mixtures has been platted against the fineness of the cement.

The length of the report makes it impossible for us to reproduce it in full, but we give some of the diagrams, which are of special interest.

*Figs.* 16 and 17 are diagrams for mortar tests made of sand of six different gradings at ages ranging from 7 days to 1 year.

Of the diagrams showing the relation between the strength of concrete and fineness of cement in Series 118 and 120 for cements K and L, we give *Figs.* 20 and 21 dealing with Series 118.



# CONCRETE PILES.

*We give some short particulars and illustrations below of a new system of Concrete Piles, patented in Switzerland, which may be of interest to engineers and others.—ED.*

An ingenious method for increasing the bearing power of piles by enlarging their feet or by producing enlargements at any other suitable part of the length has been patented by Mr. Wilhelmi, a Swiss engineer. The enlarged positions may be produced either by means of explosives or by mechanically applied pressure.

In the former case, an iron pipe, with a wooden core, is driven into the ground in the usual manner. The core is then withdrawn and a suitable charge of explosive lowered to the bottom of the bore-hole. The iron pipe is then filled with liquid concrete, the pipe partially withdrawn, and the explosive substance fired electrically. The cavity thus formed is immediately filled with concrete, which thus forms the enlarged foot of the pile. At the same time the compressive action of the explosion consolidates the surrounding ground, giving it a density almost equal to that of concrete, and making it much firmer and better able to carry a load. The relative carrying capacities of various piles are shown in the accompanying Table:

TABLE I.—Carrying Capacity of Different Types of Piles.

| Surface soil. | | Subsoil. | | Carrying capacities of different piles each 20 ft. long | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Wilhelmi Pile. | |
| Nature. | Friction per sq. ft. | Nature. | Safe direct bearing power per sq. ft. | Wooden pile 8 in. dia. at top and 5 in. at bottom. | Tapered concrete pile 18 in. dia. at top and 5 in. at bottom. | Straight concrete pile 15 in. dia. | Shaft dia. 16 in. enlargement at foot 4 ft. dia. | Shaft dia. 16 in. enlargement at foot 4 ft., enlargement at 12 ft. from foot 4 ft. dia. |
| | pounds | | tons | tons | tons | tons | tons | tons |
| Dry clay | 600 | Firm clay or gravel. | 3 | 9·4 | 46·0 | 25·7 | 61·0 | 94·5 |
| Sand .. | 300 | Soft clay (alluvium) with subterranean water. | 1 | 4·6 | 11·0 | 12·2 | 21·0 | 35·2 |
| Soft clay | 200 | Dry sand .. | 2 | 3·2 | 15·8 | 9·7 | 32·5 | 57·7 |
| Peat .. | 150 | Silt .. . | 1 | 2·3 | 6·3 | 5·7 | 18·5 | 31·0 |

When explosives cannot be used, the boring is made as before, the pipe partially withdrawn is filled with liquid concrete. A steel cap is then fitted into the pipe and this is driven downwards by a weight of 1 ton falling 9 ft., so that if the column of concrete is 18 ft. high and weighs 2,900 lb., the total ramming

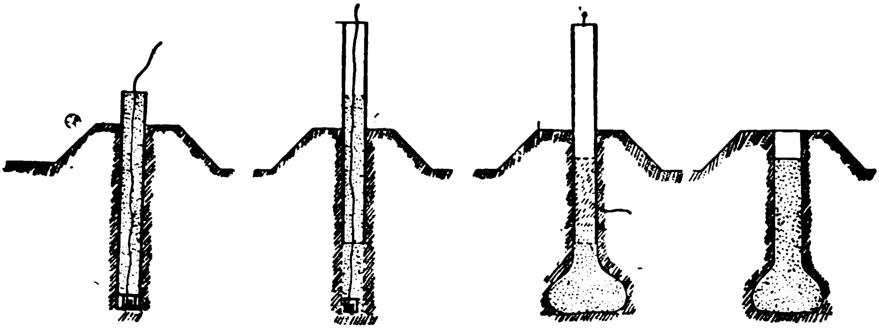


Fig 1. Formation of the Explosive Pile.

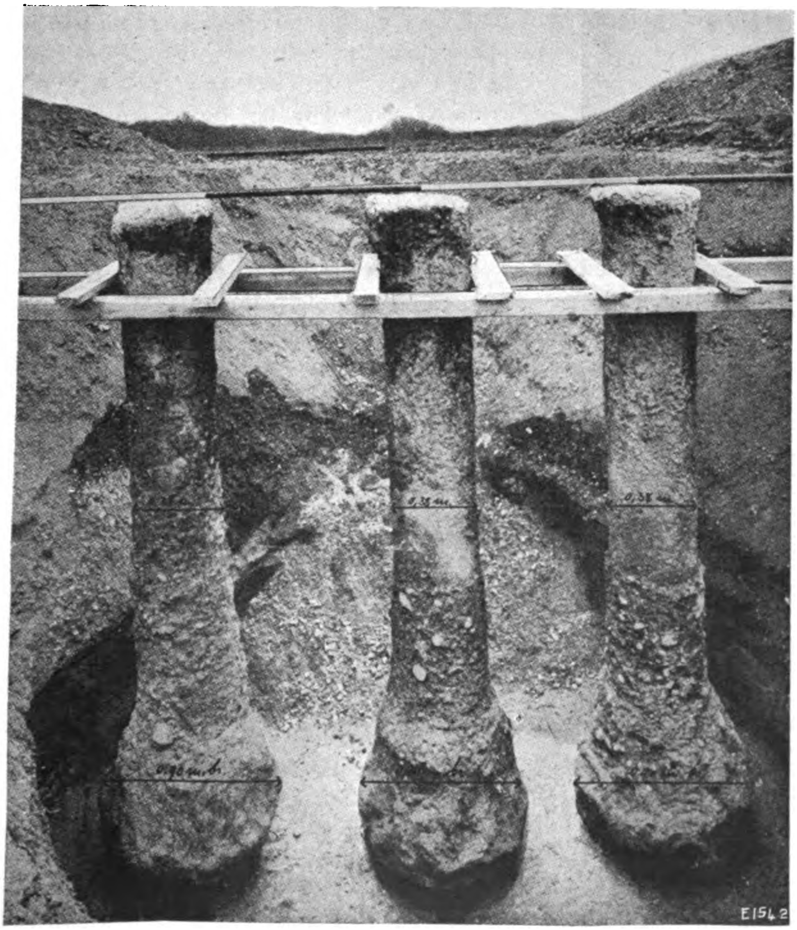


Fig. 2. A Group of Explosive Piles so close together that the bases nearly touch one another.

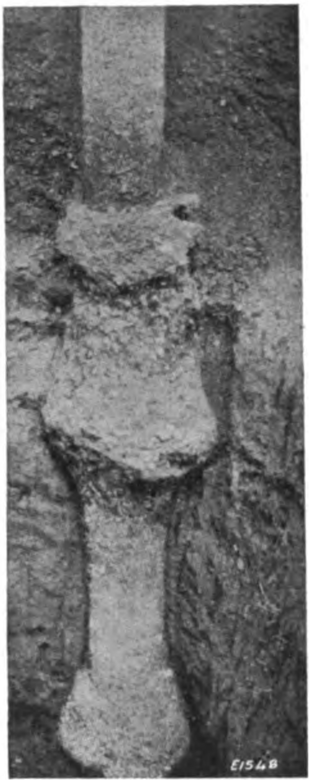


FIG. 3. EXPLOSIVE PILE, SHOWING ENLARGEMENT AT FOOT AND BASE.

effect will be about 20,000 foot-pounds. After the pipe has been driven down about 3 ft. it is raised again, refilled with concrete and again driven downward as before, these operations being continued until the foot of the pile has attained the requisite diameter or until the resistance of the ground does not permit any further enlargement of the foot of the pile. If required, similar enlargements can be made at any part of the pile, so that each pile could be provided with half a dozen enlargements.

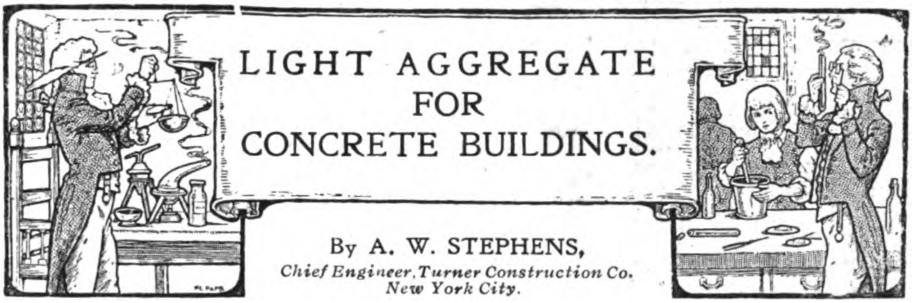
The piles can be reinforced if desired, though this is seldom considered necessary. With either explosives or pressure, using a common pile-driver, ten or more piles can be placed each day, so that this method is expeditious as well as cheap. There is also a saving in the length of the pile as the enlarged feet enable much shorter piles to be used with perfect safety.

A test was made on a 15 ft. pile with the foot enlarged to 3 ft. diameter by pressure at St. Gall Railway Station, in a subsoil of peat containing subterraneous water, by loading the pile with 43 tons. No further settlement occurred. A similar test of a pile with the foot enlarged by explosives was made at Lucerne Railway Station with the same result.

A modification of this method of piling has been patented for the production of holes into which ordinary piles may be driven. In this case, the lower end of the boring pipe is made wedge-shaped (*Fig.* 1) and is partially filled with liquid concrete. The pipe and concrete are then driven downwards into the ground to the requisite depth. When the foot has been enlarged to the desired extent, the pipe is raised and an enlargement made rather higher up, this process being repeated until a succession of enlargements has been made, the concrete column thus becoming wedge-shaped, and may be withdrawn with an ordinary light-winding gear.

The ground is penetrated by this means at the rate of 6–8 in. per blow as compared with 2–3 in. when a tube with a cast iron point is used as a boring tool, whilst the greater ease with which the tube and concrete column can be withdrawn effects a further notable saving.

The following advantages are claimed for the Wilhelmi process :—(*a*) Water kept back readily ; (*b*) readier penetration of the ground and therefore more piles driven in a given time ; (*c*) easier withdrawal of the driving tube ; (*d*) only light pile drivers needed ; (*e*) far less noise during ramming ; (*f*) minimum vibration of the ground ; (*g*) greater facilities when the working height is limited, but long piles are needed ; (*h*) great saving in time ; (*i*) great saving in cost of construction.



# LIGHT AGGREGATE FOR CONCRETE BUILDINGS.

By A. W. STEPHENS,
*Chief Engineer, Turner Construction Co. New York City.*

*Some time ago we reproduced in these pages some information regarding the use of a light-weight aggregate for concrete shipbuilding. In our contemporary "Concrete," of U.S.A., there appears a contribution on the subject as regards buildings by Mr. A. W. Stephens, of New York City. Apart from the introductory portion, we reproduce Mr. Stephens' views on the subject of a light-weight concrete for building purposes.—ED.*

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THE successful use of light weight concrete in the construction of ships has caused the question to arise as to the economic possibilities of light weight aggregate for concrete used in the construction of buildings, and a study of the question is the purpose of this paper.

For the purpose of studying the saving in materials in building construction and the consequent advantage in the use of light weight aggregate, it will be assumed that it is possible to produce concrete weighing 144 lb., 135 lb., 126 lb., 114 lb., or 99 lb. per cu. ft., respectively, by varying the kind of aggregate used. It will also be assumed that the ultimate compressive strength at the age of 28 days is 2,000 lb. per sq. in., making possible the use of an extreme allowable compressive fibre stress of 650 lb. per sq. in. with corresponding values for shear, etc.

The use of these concretes will first be considered for a typical bay 16 ft. 8 in. wide by 20 ft. long, so located in a building that its slabs, beams and girders are continuous. The slab is assumed of a minimum thickness of 4 in., the 20 ft. long beams spaced about 5 ft. 6 in. on centre are assumed as 1 ft. 8 in. total depth, and the girders are assumed as 1 ft. 10 in. total depth.

For live loads of 200 lb. and 150 lb. the beams will be 8 in. wide and the girders 12 in. wide. For live loads of 100, 75 and 50 lb. per sq. ft. the beams will be 6 in. wide and the girders 9 in. wide.

The depth of beams and girders is governed by the span and to some extent by the allowable shear value, and the width is governed principally by the amount of fireproofing required for the steel reinforcement.

The amount of concrete per sq. ft. of floor for live loads of 200 lb. and 150 lb. is ·565 cu. ft., and for live loads of 100 lb., 75 lb., and 50 lb. per sq. ft. is ·505 cu. ft.

The saving in weight of steel reinforcement per sq. ft. in the floor construction by the use of light weight concrete in place of concrete weighing 144 lb. per cu. ft. is approximately the same for live loads of 50 lb., 75 lb., 100 lb., 150 lb., and 200 lb. per sq. ft., and is as follows: For concrete weighing 135 lb. per cu. ft. the saving per sq. ft. is ·06 lb.; for concrete weighing 126 lb. per cu. ft., ·11 lb.; for concrete weighing 114 lb. per cu. ft., ·19 lb.; and for concrete weighing 99 lb. per cu. ft., ·28 lb. The quantities are based on the assumption that the reinforcing steel in the floor members will be of exact areas as required by the computations, although it is not practicable to obtain this result in actual construction.

In addition to the saving in steel reinforcement there is a saving in concrete in the columns due to the reduced weight of the floor construction. To determine this saving a six-storey building will be assumed, each storey height being 12 ft. The allowable compression on the concrete in the columns is assumed at 500 lb. per sq. in.

The saving in concrete averages approximately ·8 cu. ft. per storey for 135 lb. concrete; 1·7 cu. ft. per storey for 126 lb. concrete; 2·7 cu. ft. per storey for 114 lb. concrete; 4·2 cu. ft. per storey for 99 lb. concrete. Expressed in terms of cubic feet of concrete per sq. ft. of floor, this saving is as follows: For concrete weighing 135 lb. per cu. ft., ·0026 cu. ft.; for concrete weighing 126 lb. per cu. ft., ·0055 cu. ft.; for concrete weighing 114 lb. per cu. ft., ·009 cu. ft. ; for concrete weighing 99 lb. per cu. ft., ·0128 cu. ft.

In considering the saving in concrete and steel reinforcement given above, it should be noted that the slight saving in concrete in the footings has not been included. In order to determine in this case when it is more economical to use light weight concrete than concrete weighing 144 lb. per cu. ft., it would be assumed that concrete weighing 144 lb. per cu. yd. costs $8.10 per cu. yd., and that steel reinforcement costs 4c. per lb. in place. On this basis it will be more economical to use light weight concrete when it costs less per cu. yd. than the units covering this case in Table 1.

In the case of a 20 ft. square bay of flat slab construction a similar investigation shows that it will be more economical to use the light weight construction when it costs less per cu. yd. than the units given in Table 1 for this case.

In order to determine the advantages in the use of light weight concrete, having high compressive values, it will be assumed that it is possible to produce a light weight concrete weighing 135 lb. per cu. ft., with an ultimate compressive value of 2,500 lb. per sq. in., permitting the use of an extreme allowable fibre stress in compression of 800 lb. per sq. in. with corresponding values in shear, etc.; a 126 lb. concrete with an extreme allowable fibre stress in compression of 1,100 lb. per sq. in.; a 114 lb. concrete with an extreme allowable fibre stress in compression of 1,400 lb. per sq. in., and a 99 lb. concrete with an extreme allowable fibre stress in compression of 1,500 lb. per sq. in.

On the above basis, and assuming the cost of steel reinforcement and concrete as before, it is found that for a continuous slab supported on two sides on beams that the use of light weight concrete will be more economical than 144 lb. concrete, when it costs less per cu. yd. than the units given for this case in Table No. 2. The units as given take into consideration the saving in concrete in columns as in the first case.

In the case of the beam and girder construction, with a bay 16 ft. by 8 in. by 20 ft., the light weight concrete having the high stress values for live loads of 50 lb., 75 lb., 100 lb., 150 lb., and 200 lb. per sq. ft. will be more economical than 144 lb. concrete, when it costs less per cu. yd. than the units given for this case in Table No. 2.

For flat slab construction, 20 ft. square bay with light weight concrete of high stress values, it is found that the light weight concrete is more economical than 144 lb. concrete, when for the several live loads the cost per cu. yd. is less than the units given for the cases as noted in Table No. 2.

No attempt has been made in this investigation to develop new types of building construction to which the use of light weight concrete might be especially adapted.

These studies serve to indicate the conditions to be met in the use of light weight aggregate if light weight concrete is to compete with that commonly used in building construction.

CHIEF ENGINEER, TURNER CONSTRUCTION CO., NEW YORK CITY.

TABLE 1.

COST PER CU. YD. OF CONCRETE.

| Weight per cu. ft. | 144 lb. | 135 lb. | 126 lb. | 114 lb. | 99 lb. |
|---|---|---|---|---|---|
| 16 ft. 8 in. by 20 ft. bay, beam and girder construction. Live load per sq. ft. 50 lb., 75 lb., 100 lb., 150 lb., 200 lb. | $8.10 | $8.25 | $8.40 | $8.60 | $8.90 |
| 20 ft. sq. bay, flat slab construction— Live Load per sq. ft. | | | | | |
| 50 lb. | $8.10 | $8.25 | $8.40 | $8.60 | $8.90 |
| 75 lb. | 8.10 | 8.25 | 8.40 | 8.60 | 8.85 |
| 100 lb. | 8.10 | 8.25 | 8.40 | 8.85 | 9.10 |
| 150 lb. | 8.10 | 8.30 | 8.50 | 8.70 | 9.20 |
| 200 lb. | 8.10 | 8.50 | 8.65 | 8.95 | 9.20 |

NOTE.—Extreme compressive fibre stress value 650 lb. per sq. in.

TABLE 2.

COST PER CU. YD. OF CONCRETE.

| | | | | | |
|---|---|---|---|---|---|
| Weight per cu. ft. and extreme fibre stress value in compression | | 144 lb.<br>per<br>cu. ft.<br>655 lb. | 135 lb.<br>per<br>cu. ft.<br>800 lb. | 126 lb.<br>per<br>cu. ft.<br>1,100 lb. | 114 lb.<br>per<br>cu. ft.<br>1,400 lb. | 99 lb.<br>per<br>cu. ft.<br>1,500 lb. |
| Continuous slab between two beams for live loads, 50 lb., 75 lb., 100 lb., 150 lb., 200 lb. per sq. ft. | | $8.10 | $8.50 | $9.10 | $9.50 | $9.80 |
| 16 ft. 8 in. by 20 ft. bay, beam and girder construction. Live loads, 50 lb., 75 lb., 100 lb., 150 lb., 200 lb. | | 8.10 | 8.50 | 9.10 | 9.55 | 9.80 |
| | Live Load per sq. ft. | | | | | |
| 20 ft. sq. bay, flat slab construction— | | | | | | |
| | 50 lb. | 8.10 | 8.25 | 8.40 | 8.60 | 8.90 |
| | 75 lb. | 8.10 | 8.25 | 8.40 | 8.60 | 8.85 |
| | 100 lb. | 8.10 | 8.50 | 8.60 | 8.80 | 9.10 |
| | 150 lb. | 8.10 | 8.70 | 9.15 | 9.45 | 9.70 |
| | 200 lb. | 8.10 | 9.05 | 10.00 | 10.20 | 10.50 |
| | | 144 lb.<br>per<br>cu. ft.<br>630 lb. | 135 lb.<br>per<br>cu. ft.<br>600 lb. | 126 lb.<br>per<br>cu. ft.<br>1,100 lb. | 114 lb.<br>per<br>cu. ft.<br>1,400 lb. | |

## MEMORANDA.

**Simple Apparatus Repairs: Defective Concrete Columns.**—Mr. J. D. Evans, in *Engineering News-Record*, gives the following particulars for repairing a too dry concrete, not puddled enough, causing peeling and disintegration at the bottom of columns. These columns, 15 ft. high and 20 in. square, were reinforced with eight 1⅛-in. rods bound with spiral reinforcement.

The concrete was cut off level, and a wood form placed around the bottom of the column—the top board leaning out so as to form a hopper—and a piece of ½-in. pipe was put in at the high point of the cut, extending from the centre of the column out through the form. A fine gravel concrete was put into the hopper, thoroughly rammed, and allowed to set for about two weeks. The forms were removed, and the patched part was trimmed to conform with the rest of the column.

The voids in the repaired portion of the column were then filled with pure cement grout forced in through the pipe by a compressed air apparatus made from a piece of 3-in. water spout, the top being sealed and having a valve from an automobile tyre set in the centre. The bottom was sealed also. From near the base a smaller pipe extended to about the top of the tank. After the grout had been poured in, this was connected by an air-tight line to the pipe cast in the column. By the use of an automobile-tyre pump the grout was forced into the voids. After pumping for some little time water could be seen seeping out on the sides of the columns, showing that the scheme was working out satisfactorily. Several buckets of grout were forced into a few columns, and undoubtedly filled all voids due to the shrinkage of the concrete.

**Fluid Concrete for Casting.**—The use of fluid concrete in the construction of reinforced concrete is rapidly increasing as it is more uniformly distributed throughout the mass. The different behaviour of fluid concrete in impervious iron forms and in porous and water-absorbing shuttering was investigated by Gary in 1914. To secure further data F. Brumlik carried out a series of investigations using iron, wood and plastic moulds respectively and found that cubes made in plastic moulds were much stronger, hardened more rapidly and uniformly and more nearly resembled those made of stiff-plastic concrete. From this he concludes that iron and oiled wood forms and shuttering are unsuitable for very fluid concrete. Test tubes made in plaster moulds resemble those cut from larger structures in actual building practice. The plaster must be renewed after being used four or five times, but as they are cheap and easily prepared this frequent renewal is not serious.—*Beton u Eisen.*

# The POSITION OF THE REINFORCEMENT IN CONCRETE.

By J. WAALKENS.

*The following article deals mainly with the opinions held and conclusions arrived at on this subject among continental engineers and experts.—E.D.*

THE position of the reinforcement in concrete should be determined chiefly in accordance with the rules regulating the strength of the latter, but unfortunately during the last few years a number of accidents have resulted from neglecting to cover the steel rods with a sufficiently thick layer of concrete. In order to prevent the formation of rust, anti-rust coatings or other rust-preventives are sometimes used, but their value is insignificant, and it is, in every way, better to use sufficient concrete to prevent any water reaching the rods. In order to ascertain the minimum thickness of this layer of concrete, the author collected the following data from the different specifications used by various States on the Continent of Europe.

| Specifications. | Least permissible Distance of the Bars from the Surface of the Concrete. | | |
|---|---|---|---|
| | Floors (Plates). | Beams. | Columns. |
| | mm. | mm. | mm. |
| Dutch, 1912 .. .. | 10 | 15 | 15 |
| Dutch, 1918 .. .. | 10 (20)* | 25 (35)* | 35 (50)* |
| German, 1916.. .. | 10 (20)† | 15 (20)† | 15 (20)† |
| Swiss, 1915 .. .. | 10 | 20 | — |

From the above table it is evident that in general a layer of concrete of 10 mm is considered sufficient to prevent the formation of rust on the reinforcement, though the German specification requires a minimum distance of 20 mm. for concrete exposed to the open air.

In studying the different conditions of buildings of reinforced concrete erected during the last ten years, the author has arrived tentatively at the following conclusions :—

(i.) All the buildings he has visited show a variable number of shallow or deep cracks on the surface of the concrete.

(ii.) In structures having continuous cracks caused by very heavy loads, settlements, etc., an insignificant formation of rust was discovered wherever the layer of concrete was sufficiently solid and homogeneous to protect the bars used as reinforcement.

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* These numbers in parentheses refer to concrete exposed to high temperatures in case of fire.
† These numbers in parentheses refer to concrete exposed to the open air.

(iii.) Shallow cracks in the plastering gave no cause of complaint with regard to rust formation.

(iv.) On places where the thickness of concrete over the reinforcing rods was scanty and porous rust was found, and in several instances whole bars and braces had completely perished.

(v.) In nearly all the buildings examined, places were discovered where the layer of concrete was scanty, porous and not homogeneous.

(vi.) A satisfactory remedy consists in covering the reinforcement with a layer of concrete 2 to 2·5 cm. (say 1 in.) thick; in several cases in which a solid and homogeneous composition could be relied upon a less thickness sufficed.

(vii.) In general, the destruction caused by an insufficient and porous layer of concrete appeared to be much more serious than the effect caused by cracks in the concrete.

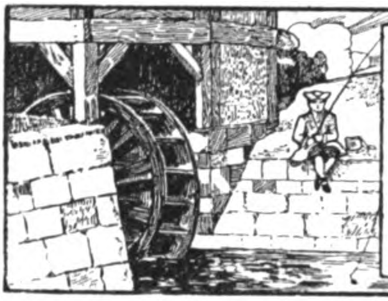
In using Portland cement with a low shrinkage and a lean concrete a large number of thin iron rods, instead of fewer thick ones, will largely prevent cracks due to contraction, though it seems impossible to prevent entirely the formation of surface cracks, as internal pressures in the concrete may produce surface cracks.

By taking care that the iron rods are a sufficient distance from the surface of the concrete, and that the distance of the rods from each other is greater than their diameter, thus enabling the concrete to cover every rod, the formation of cracks does not appear to be serious, provided the concrete is solid and homogeneous and that it has been placed properly. Unfortunately, as stated above, in most cases such careful work is sadly lacking in parts of almost every building examined, and therefore the author recommends that the distance between the rods and the surface of the concrete should not be too small. The distance of 10 mm. (in the German instructions 20 mm.) mentioned above seems to be insufficient. Wörnle recommends a distance of at least 3·5-4 cm. (1½ in.). The thickness of the concrete should not be excessive, as the reinforcement must remain in the zone of the chief tensile stresses, which is near the bottom of a beam and near the outside of a pillar or pile.

From his experiments and practice the author suggests:—

(*a*) In all cases the minimum distance of the reinforcement from the surface of the concrete shall be 3 cm. (1¼ in.).

(*b*) When the reinforced concrete is placed under water or in wet ground it will shrink little or not at all, and the danger of cracking will be less except when they are due to irregular settlements of the foundations. Yet even in such cases the smallest thickness required seems, to the author, to be at least 3 cm. (1¼ in.).



# CONCRETE BLOCKS FOR LINING RESERVOIRS.

OWING to the war-time difficulty of obtaining in India the steel reinforcement generally used when a concrete face is to be applied to a large area, other methods had to be considered in the construction during the war of reservoirs of 2,500 tons capacity each to store the liquid fuel used on the locomotives in the Karachi district of the North-Western Railway. The tanks are 8 ft. 6 in. high, and 60 ft. by 40 ft. interior measurements, and were constructed under the superintendence of Mr. N. Pearce, A.M.Inst.C.E., executive engineer to the North-Western (India) Railway, who described the construction of the project in ***Indian Engineering.*** In considering an alternative to reinforced concrete, mass concrete was ruled out owing to the strict supervision necessary in the mixing and depositing of this type of construction, the shuttering which would be required and the necessity of providing expansion joints.

The thickness of the concrete face to be applied was 9 in., and it was finally decided to use blocks 11⅞ in. by 5⅞ in. on the face by 4½ in. deep. The small size was adopted so that the blocks would be easy to handle and also bond in with the brickwork. They were laid like ordinary bricks on edge, two bricks forming the 9 in. lining required. The blocks were at first made by hand, but it was found that these did not attain the requisite compactness or density, and this method was discarded in favour of machine mixers and a " Jagger " vibrating table for making the blocks. As the lining was required to be proof against the absorption of oil fuel a rich mixture was decided upon, as follows :—One part cement, 1½ parts clean sharp sand and 3 parts clean gravel screened to ¼ in. In laying the hand-made blocks a mortar of neat cement was used, but this was found to be unsatisfactory, as if made wet enough to work easily into the vertical joints it was too wet to stand up in the joints on the sloping sides of the tank ; shrinkage cracks also occurred during setting. The mortar used in laying the machine-made blocks was composed of 1 part cement to 1 part sand, and this was found to be satisfactory. The blocks were laid like ordinary brickwork, breaking joint as much as possible.

Tests were carried out to ascertain how far the blocks were impervious to the penetration of the liquid fuel, sample blocks being immersed in the oil for a period of seven days. These tests showed that with the hand-made blocks the oil penetrated to a depth of 1⅞ in. in the week, with the exception that no appreciable penetration took place on the top face of a block made with a very wet mixture. This was due to the cement in the block working upwards whilst setting, with the result that the top face was practically coated with a layer of neat cement. With machine-made blocks the penetration in the same period was found to be only about ½ in., and fairly regular on all faces. On the inside surface of the tank, the blocks are covered with a final coating of cement plaster, the hand-made blocks with ⅝ in. of neat cement and the machine-made blocks with a mixture of 1 part cement and 1 part sand to a depth of ⅝ in.

Observations as to the loss of the contents of the tanks by percolation through the walls show that the losses tend to diminish as time proceeds. With hand-made blocks and neat cement plaster, no measurable loss was found in a period of 20 days after the tank had been in use for some few months, and observations on a tank constructed with machine-made blocks and a lining of 1 part cement and 1 part sand show a loss of 0·05 per cent. of the contents during a period of 43 days.

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## MEMORANDUM.

**A Concrete Bridge 1,100 ft. Long.**—A concrete bridge of unusual length, built to connect the coal depot at Floreffe station with the quay on the Sambre, possesses several novel features. It consists of an upper bridge 1,100 ft. in length and 50 ft. high with accommodation for two parallel rows for vehicles of 1 ton capacity, a lower bridge 600 ft. in length for vehicles of 20 tons capacity, and a tunnel 533 ft. in length which forms an extension of the upper roadway. The two roadways are 20 ft. apart and are supported above the river Sambre by two skeleton arches united by steel ties at the springs and keystones, each arch being 180 ft. span and 380 ft. rise.

The upper roadway is formed of a pavement supported on two series of parallel ties 50 and 60 ft. in length, partly sunk in the ground, and fixed in position by means of winches. Tests of the static strength of the structure were made on the wider part of the Sambre, the loads being 150 lb. per sq. ft. on the upper roadway, 50 lb. per sq. ft. on the footpath, and 200 lb. per sq. ft. on the carriage way of the lower road.

As a matter of fact with the aim of submitting the ties which support the lower bridge to the same forces as at the time of the dynamic tests, the whole weight of the bridge, probably 400 lb. per sq. ft., was confined solely to the lower roadway.

With a maximum load of 212 tons the greatest deflection observed was 0·88 in. and after the load had been removed there was a permanent deflection of 0·32 in.

The abutments showed a slow vertical sinking of about 0.08 in. and a horizontal one of 0·12—0·16 in. A variation of temperature of 12° during the period when the bridge was subjected to the full testing load varied the deflection by 0·24—0·28 in. on account of the expansion of the reinforced concrete and thus showed the necessity for suitable ties between the arches. For the difference in temperature in winter and summer a deflection of at least 1 in. is anticipated. To permit longitudinal expansion the bridge was constructed in two parts with a 4-in. space between them ; this space varies from 3·0 to 4·4 in.

The dynamic tests were made by placing a load of 110 tons on the upper bridge and drawing a wagon weighing 16 tons on the lower one, a deflection of 0·20 in. being obtained in the upper bridge and 0·12 in. for the lower one—*i.e.*, a total of 0·32 in. as compared with a permissible deflection of 2·12 in. (10 per cent. of the span). When the wagon was moved back a rise of 0·04 in. on one side and a depression of the same amount on the other side was recorded. On removing the load the deflections disappeared completely. The design and supervision of the bridge was executed throughout by M. Ch. Tournay. A similar structure has been built by the same engineer for the Werister coal mine.—*Le Béton Armé.*

# CONCRETE IN THEORY AND PRACTICE.

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

By OSCAR FABER, O.B.E., D.Sc., etc.

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED.*

### CHAPTER IV.—*continued.*

### *Shearing Resistance of Concrete Beams.*

54. The failure on diagonal planes, mentioned in Par. 53, will be better understood after a careful examination of *Fig.* 9, which illustrates many things connected with shear.

Consider now a beam well reinforced so that it will not fail near the middle where the bending moment is greatest. Suppose now such a beam happened to crack along planes, as in *Fig.* 9 (*a*). Evidently the middle part with the load on it would drop away and complete failure occur. Suppose now we stick the three parts together, with glue, cement, or any other adhesive, it is clear the beam will be sound again and will carry such a load as just breaks the joint again. It is quite clear that the stress *V* in *Fig.* 9 (*a*) is across the joints a tensile stress, as the middle pulls away from the ends. In practice, the beam is not broken, but will break if the tensile strength of the concrete across these planes is not sufficient.

This is how failure by shear in concrete beams nearly always occurs.

55. Consider now *Fig.* 9 (*b*). Here the beam is considered as divided by diagonal planes, but at right angles to those previously referred to.

It is clear that the centre part is pressed by the load against the end parts, and that the stress at the joints is one of compression. The beam will carry a load if the centre part is carefully fitted to the two ends, without any glue or adhesive whatever.

56. We see, then, that the ends of a beam are in a condition of tension across diagonal planes, and of compression on planes at right angles, as in *Fig.* 9 (*c*). Now the beam breaks if the tension or compression becomes greater than the concrete will stand.

It has already been explained that concrete is about ten times as strong in compression as in tension, and therefore the tension failure, as in *Fig.* 9 (*a*), occurs first and is the chief danger to guard against.

It is, however, possible to reinforce the tension planes so much that the concrete eventually fails on the compression planes.

In steel plate girders, where compression in a thin web causes buckling, the compression stresses are the chief danger to be guarded against.

57. We must now see what loads we can expect a beam to carry without failing in this way.

Experiments show that these failures occur roughly at 45°, so we will confine our attention to such cases.

Consider, then, a tensile stress $t$ lb. per sq. in. across a plane at 45°, as in *Fig.* 9 (*d*).

If the depth of beam is $a$, then the length along the diagonal plane is $1{\cdot}414\,a$ and the area of the plane is $1{\cdot}414\,a.b.$, where $b$ is the width of the beam.

Hence the total tension across the plane is

$$\begin{aligned} T &= \text{area} \times \text{stress.} \\ &= 1{\cdot}414\,a.b \times t. \end{aligned}$$

Now this force is a diagonal one, which can be resolved into a vertical and a horizontal component, as in the right-hand diagram of *Fig.* 9 (*d*).

In accordance with the triangle of forces theorem, it follows that at 45° the vertical and horizontal components will be only $\frac{1}{1{\cdot}414}$ of the diagonal force.

Now $S$, the vertical component, is the part which prevents the centre part of the beam from dropping from the end, and is therefore important.

Hence

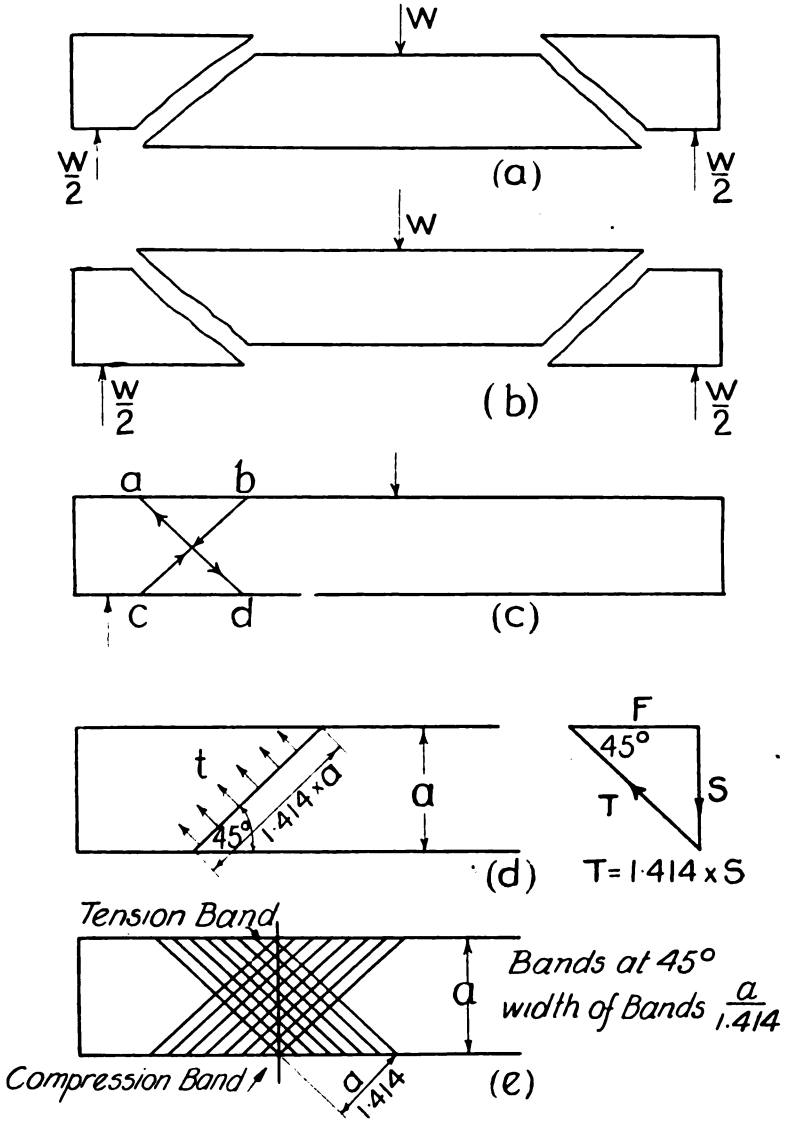


FIG 9

To Illustrate shear in beams.

$$S=\frac{T}{1\cdot414}$$
$$=\frac{1\cdot414\,a.b.t}{1\cdot414}$$
$$=a.b.t$$

In other words, *the safe shear across a beam section is the area of the section multiplied by the safe tensile stress.*

58. This is very important. With concrete, we take about 60 lb./in.$^2$ as the safe tensile stress, and therefore 60 multiplied by the $V$ area of the beam gives us the cross sectional safe shear.

Now clearly the force causing the centre part to drop is $W$, or $\frac{W}{2}$ at each end, and this is therefore the shearing force $S$.

So if we see that $\frac{W}{2}$ is not greater than 60 times the area of the beam or

$$S=\frac{W}{2} \text{ not greater than } 60\times a.b$$

failure by shear will not occur.

The expression $\frac{S}{ab}$, the shear divided by the area, is called the shear stress, but really means nothing, because failure occurs either by tension or compression, as explained.

The horizontal component $F$, in *Fig.* 9 (*d*) goes to produce the horizontal compression at the top of the beam and the horizontal tension at the bottom.

59. Another method of viewing the matter is to consider a vertical plane across a beam, as in *Fig.* 9 (*e*), and consider the forces acting across it.

The vertical components of all these forces must resist the vertical shear at the section.

Now there are an infinite number of lines at 45°. which can be drawn in the beam to represent tension forces, but we are only concerned with those passing through the one vertical section drawn. These give a tension band whose width is less than the depth of the beam, and is, in fact,

$$\frac{a}{1\cdot414}$$

as can be shown or tested by measuring.

Hence the total tension is

$$T=\frac{a}{1\cdot414}\times b\times t$$

where $t$ is the tensile stress, and the vertical component of this force is

$$T_v=\frac{1}{1\cdot414}\times\frac{a}{1\cdot414}\times b\times t,$$
$$=\frac{a.b.t}{2}$$

Now there is also a compression band which crosses the vertical section. The compressive stresses are equal to the tensile stresses, as is clear by realising diagrams 9 (*a*) and 9 (*b*) that the force is the same in both cases, and the area of the planes also the same.

It will be clear that the compression band has the same width as the tension band, and, as the stress is the same, the vertical component

$$C_v=\frac{a.b.t}{2} \text{ as before.}$$

Hence, the total shear across the section

$$S=T_v+C_v=\frac{a.b.t}{2}+\frac{a.b.t}{2}$$
$$=a.b.t \text{ as before.}$$

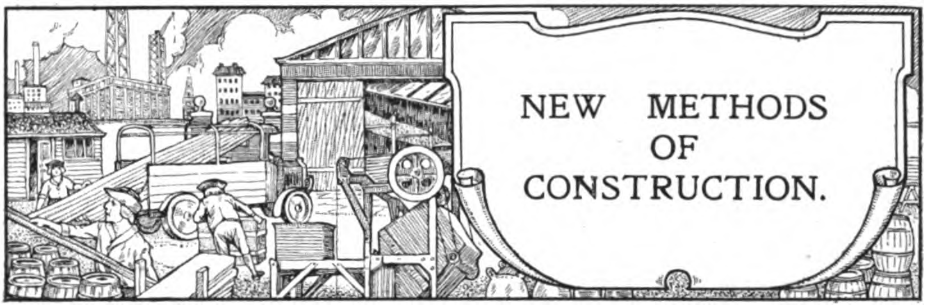
This method of taking the vertical component of all forces across a section is particularly useful in considering complicated reinforced sections.

60. Example: A beam, 12 in. deep, 10 in. down to steel, 8 in. wide, is designed strong enough to resist bending. What is the safe load it will carry without failure by shear, and without shear reinforcement?

Now the depth which may be reckoned in shear is strictly the depth between the centre of tension and the centre of compression, which is, as a rule, about ·88 times the depth to the steel.

$$\text{Hence } a=\cdot88\times10 \text{ in.}=8\cdot8 \text{ in.}$$
$$b=8 \text{ in.}$$
$$t=60 \text{ lb. per sq. in.}$$
$$\therefore \text{Shear }=8\cdot8\times8\times60.$$
$$=4{,}224 \text{ lb.}$$

As the shear is half the load on the beam, the safe load is $W=8{,}448$ lb.



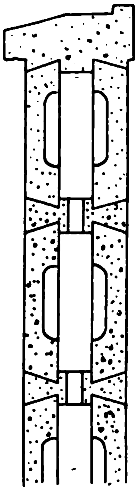
# NEW METHODS OF CONSTRUCTION.

*In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—ED.*

## AUTOBOND BUILDING BLOCKS.

THE Autobond building blocks, here described and illustrated, claim, within practical limits, to overcome some of the difficulties which at the present time prevail in the building world and without departing from traditional building as it is understood.

The features of the system are three blocks, named for identification purposes :—blocks, bonders and coigns. The first cost of production of the blocks is slightly higher than ordinary bricks or blocks, a little more care being needed in manufacture than if they were rectangular in form, but this increase in first cost is said to be more than counterbalanced in consequent saving of time and labour. A minimum of mortar is needed and no metallic wall ties are employed in erection, as the form of the blocks provides an efficient tie.



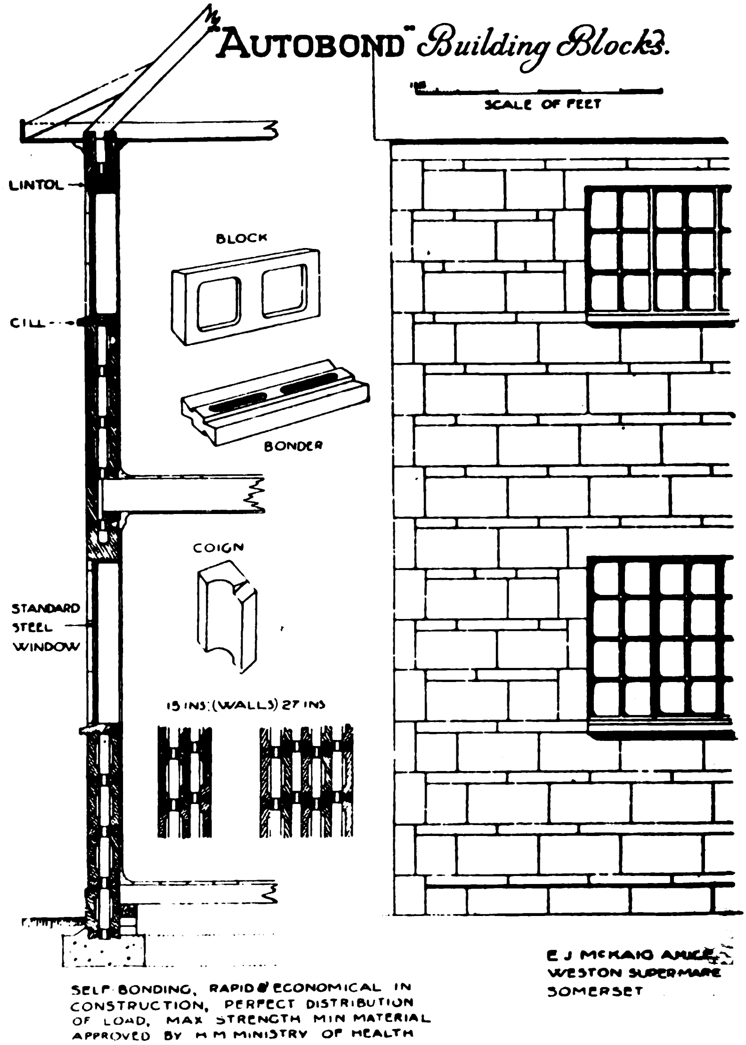
The designers point out that, in considering cavity walls of brick and some types of concrete block, it will be found that more often than not they are made up of two thin walls separated by a cavity and not a wall with a cavity or cellular interior.

In the case of the system under review it is claimed that a 9-in. wall is a 9-in. wall, and consequently all loads due to the floors and roof that are superimposed are distributed over and carried by the whole wall, and not by uneven loading on part of it only. Although a continuous cavity is provided for throughout the length and height of the wall, there are certain points where the wall is solid. At first sight this may be looked upon as an objection, inasmuch as at these points condensation may be apparent. But when it is taken into account that the solid proportion of the wall is 5 per cent. only of the total surface, it cannot be seriously considered as being in any way an objection. The remaining 95 per cent. would easily disperse any small amount of condensation, should any occur, which is highly improbable.

Each of the units comprising the system is arranged to be of such size and weight that it can be easily handled without lifting tackle. Once the job is set out and a course of bonders laid, the blocks are then built on the bonders, breaking joint, the bevelled edge of the block fitting into the corresponding groove of the bonder and automatically keeping the alignment. The work then proceeds by the addition of another course of bonders, which in turn correct the blocks to the vertical, or, in other words, automatically plumbs the work as it proceeds.

Cement grout is recommended as mortar for the horizontal joints, and can be applied either by dipping the edge of the block in it or with a brush ; the bevelled edges of the blocks have been found to possess a great advantage over tongues and grooves inasmuch as they are not so liable to damage in handling and transit.

**The illustration shows a typical section of a 9 in. wall as applied to ordinary house construction and the manner in which roof and floor connections are made, as well as walls of greater thickness than 9 in. are built, using the same type of block.**


"AUTOBOND" Building Blocks.
SCALE OF FEET
LINTOL
CILL
STANDARD STEEL WINDOW
BLOCK
BONDER
COIGN
15 INS (WALLS) 27 INS
SELF BONDING, RAPID & ECONOMICAL IN CONSTRUCTION, PERFECT DISTRIBUTION OF LOAD, MAX STRENGTH MIN MATERIAL APPROVED BY H M MINISTRY OF HEALTH
E J McKAID AMICE
WESTON SUPERMARE
SOMERSET

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## MEMORANDUM.

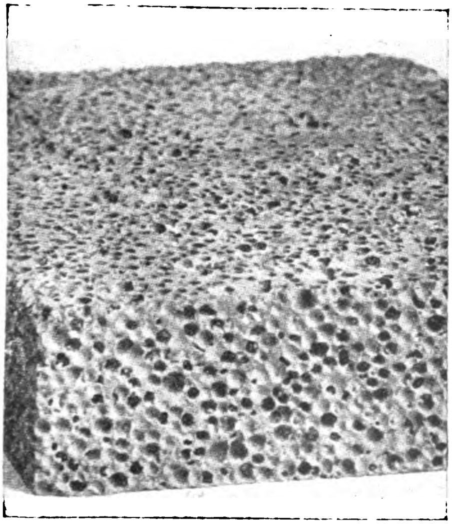
**New Cooling Towers at Oldham.**—The foundations for these cooling towers have recently been completed in reinforced concrete to designs prepared in the engineering department of Messrs. Peter Lind & Co., Westminster, S.W.

The same firm has also recently been awarded the contract for the new workshops for the Gas Light & Coke Company at their Beckton works. The buildings will be of reinforced concrete throughout, and the erection of same will be carried out by Messrs. Peter Lind's own staff of workmen.

# POROUS CONCRETE.

In our last issue we briefly referred to a method of manufacturing porous concrete ("Porete") which is being developed in the United States, and we are now able to give some further particulars of this interesting and novel process. The porosity of the material is obtained by mixing with Portland cement and sand a quantity of a substance similar to wax, made in the form of pellets, about the size of gun-shot. These pellets are sufficiently strong to withstand damage during the mixing of the concrete, but are very susceptible to heat and melt at a temperature below that which has any detrimental effect on the concrete. To obtain the voids, the concrete is therefore subjected to heat after it has been moulded into slabs, with the result that the wax-like pellets melt and run off, when the material is recovered and prepared for use again. The composition of the substance of which the pellets are formed is not divulged, and the whole process is covered by United States patents. There is no mention of any other aggregate being used except Portland Cement and fine sand, and the pellets have no harmful effect on the mixing or setting.

The material is extremely light, weighing only about 50 lb. per cu. ft., or very little more than timber. Although production on a commercial basis has only recently become possible, slabs made in a laboratory some 12 months ago are in good condition, and owing to the setting of the cement are harder than when first made. It does not appear that the material has been developed in the direction of a weight-bearing constructional material, or that tests have been made on these lines, but slabs 1½ in. thick, and covered with felt, tar and slag, have been tested to an ultimate strength of 350 lbs. per square foot. So far the slabs are being made to a standard dimension of 32 in. by 24 in., and in thicknesses of 1 in. and 1½ in., the former being for walls and the latter for roofs. The slabs are reinforced with light 2 in. mesh wire netting, and while one surface is left rough and porous, the other is made smooth and flat in the mould.



"Porete" Porous Concrete: Actual Size.

Method of Fixing "Porete" Slabs.

The slabs of this size are intended for use in the covering of steel-framed buildings, and a large factory of this type has been erected by the Porete Manufacturing Co., at Newark, N.J., for the manufrcture of the slabs. The horizontal members of the steelwork are placed at 32 in. intervals in order to carry the slabs, which are attached, with the smooth surface to the inside, by means of strong galvanised iron clips. The exterior is then water- proofed with two coatings of Portland cement stucco. The roof slabs are clipped to the steel framework in the same way, and waterproofed with a covering of felt, tar and slag. Nails may be driven into " Porete " without injuring the material, and an experimental wall constructed with porous slabs nailed to wooden studs has been erected.

As with every other new material, the durability of this kind of concrete can only be tested with time, but it appears to be particularly rapid and economical in labour on the job. Owing to the thinness of the slabs, the walls can hardly be sound-proof, and this would be a drawback to the use of this type of construction for many purposes ; but for factory buildings, garages, &c., there should be a wide field for it. Apart from the steel erectors, no skilled labour is necessary ; no scaffolding is required, and the only tools used are hammers to bend over the clips. The porous nature of the material eliminates any question of condensation on the inside, but it is, of course, essential that the exterior should be thoroughly waterproofed.

The illustrations show a " Porete " slab reproduced actual size and the method of fixing the slabs to the framework. For these illustrations and the above particulars, we are indebted to the *American Architect*.

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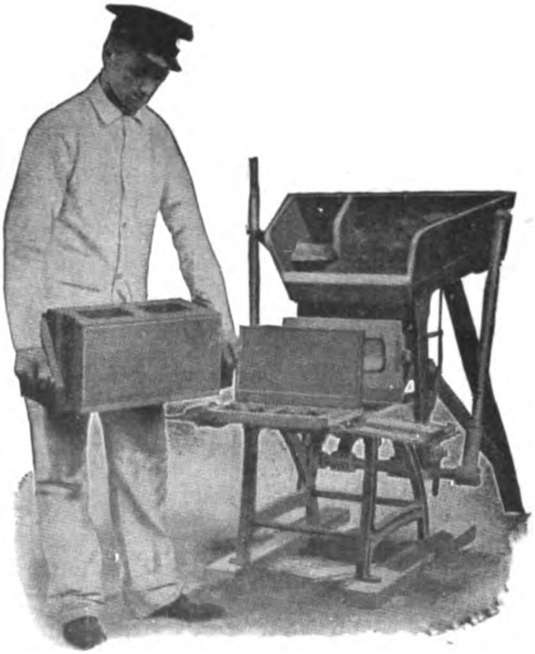

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# NEW BOOKS

## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

**Cement. By Bertram Blount, F.I.C., assisted by W. H. Woodcock and H. J. Gillett.**

London : Longmans Green & Co. Price 18s. net.

This long-looked for volume in the series of monographs of Industrial Chemistry under the general editorship of Sir Edward Thorpe resembles very closely two other volumes on the same subject by two chemists who are also, like Mr. Blount, recognised as experts in the analysis and testing of Portland cement. Although the title is by no means limited to any one type of cement and in the introduction the author clearly points out the existence of at least two broad groups of very different cements, yet for all practical purposes the volume is confined solely to Portland cement.

The first chapter, which is historical, contains little that is new, but it is lucid and brief without being overloaded with unnecessary details.

The second chapter deals with the raw materials used in the manufacture of Portland cement and includes numerous analyses of chalk, limestones, marls, clays, shales, cement rocks, slags and puzzolana. In each case the analyses add up precisely to 10,000 so that the figures relating to some constituent must have been found by deducting the remaining figures from 100, though this is not definitely pointed out. The author does not appear to differentiate between cement made from a mixture of clay and chalk or limestone and that made from blast furnace slag, though most practical users of cement who have sufficient scientific knowledge would not willingly use a slag cement when they have specified Portland cement, the properties of the two materials being quite distinct in several respects.

In dealing with puzzolana and trass in this chapter the author fails to do these materials justice. The real, and in a sense, the only purpose in adding puzzolana or trass to a concrete is in order to combine with the lime set free when the cement is wetted, and, consequently, to prevent the objectionable " washing out " which must occur where no corresponding material is used.

In Chapter III the subject of fuel is dealt with from an economic rather than from a chemical point of view. The author has reached the conclusion that producer gas is, at present, impracticable in the rotary kiln ; he clearly prefers powdered coal or oil to any other fuel and he believes that electric heating is well worth a trial in localities where coal is dear.

In the fourth chapter, which deals with manufacture, the author considers that a fused product containing 70 per cent. of lime is " perfect," and he outlines a method by which the calcination could be effected in the ordinary manner and the fusion produced electrically. The efforts of Hurry and Seaman to produce a fused slag cement in a blast furnace are also commended as " worthy of more extended trial," whilst he is of the opinion that " the manufacture of cement by fusion in a super-blast furnace (using air enriched by oxygen) will ultimately be an accomplished fact." At present the proportion of lime does not exceed 65 per cent. and the mixture is not heated above 1200°C., so that only a clinker or partially fused mass is produced.

The description of the methods of manufacture is clear and fairly full.

In the later chapters the author deals with chemical matters, and the usefulness of these chapters is increased by the inclusion of a number of the more important official specifications for Portland cement in force in various countries.

The chapter on " The Chemistry of Portland Cement " omits reference to several important researches on the subject, whilst the latest date of any reference is 1909—and in the author's own words " the Chemistry of Portland Cement . . . is in a state of flux and will remain so until far more thorough and difficult researches are made than those extant."

So far as he commits himself to any definite statement, the author appears to consider " the strength of Portland cement after setting is due entirely to the crystallisation of $Co(OH)_2$ . . . and not at all to the hydration of the silicates of aluminates" present. It is very difficult, however, to reconcile this view with the difference in the strength of lime and cement except by assuming that the "inert matter" in cement is so disposed as to bring about exceptionally favourable conditions for the crystallisation of the calcium hydrate—an assumption which requires more support than it has hitherto received.

In the chapter on the Uses of Cement it is rightly stated that "their name is legion." and the half dozen pages devoted to them might with great advantage have been trebled. Curiously enough, the author does not endorse the view that "Portland cement properly sanded will go a long way;" and he adds that "the engineer knows that if he makes an error it is better to err on the side of richness." Whilst there is certainly some truth in this statement, it would surely have been better to explain it in greater detail, as a number of failures of concrete have been proved to be due to the use of a mixture containing too much cement. The reviewer's experience is that a moderate excess of sand is less likely to do harm than a great excess of cement!

Chapter XII. deals with the effect of various substances on cement. So far as sea-water is concerned, the author believes that "long before it has been destroyed by sea water, the utility of a harbour will have disappeared." At the same time, he points out that cement immersed in sea water gradually becomes useless owing to the replacement of the free lime by magnesia or calcium sulphate or both. He does not describe methods for avoiding this, but states that the use of puzzolana is beneficial.

The effect of various aggregates—notably slags and breeze—is briefly described. The final chapter deals with the By-Products of Cement, particularly "waste heat," and "volatilised alkalies." No adequate means of recovering the former is given. For volatilising the alkalies in the kiln with a view to their subsequent recovery and commercial use, the author suggests the addition of the halogen compounds of calcium or of potash felspar to the raw mix.

Five appendices contain (i.) a list of international atomic weights, dated 1920; (ii.) a short list of factors useful in analysis, based on much older atomic weights; (iii.) three tables showing the relation of metric weights and measures to the British ones; (iv.) a short series of useful "Memoranda"; and (v,) a number of foreign specifications for cement.

The book is a useful addition to the literature on this important subject, and it is one which should be read by all who wish to be conversant with the nature and properties of Portland cement.

### Concrete for House, Farm and Estate. By Fred Ballard.

London: Crosby, Lockwood & Son.

It is probable that the lack of houses for all classes of the community is the main cause of the present unrest in the country, and the impossibility of obtaining bricks in sufficient quantities, unless ordinary building is interfered with, has made concrete constructions a necessity.

Unfortunately, concrete construction has in the Press been too often made a controversial matter, and has been referred to as a means of construction that continually involves abstruse mathematical calculations, and whilst this is undoubtedly true with regard to large buildings and engineering undertakings, the concrete work for small buildings raises few problems that cannot be solved by the common sense of the ordinary workman.

We therefore welcome this volume, which is written in so simple a manner that it is intelligible to both the practical man and the non-technical reader.

The book is profusely illustrated with photographs, details and diagrams showing how various constructions may be carried out, and whilst it is doubtful whether the ordinary farmer could, unaided, manipulate many of the constructions shown, it is certain that with the aid of a semi-skilled workman much trouble could be formed on the farm and small-holding.

The contents of the volume comprise cottage and farm buildings, stores, kerbs, posts, and other desiderata of the farm and estate, and many of the notes and ideas expressed are worthy of study and consideration by the specialist in these types of structures.

### Who's Who in Engineering. Edited by John Ed. Sears, C.B.E.

London: The Compendium Publishing Co., 93 and 94 Chancery Lane. Price 25 - net.

This is the first edition of a new reference book designed to be of special use to all engaged in the engineering profession and the engineering and allied trades. The volume is a development of the "Who's who" principle on practical lines.

The "Who's who" section in the engineering profession and in the engineering and allied trades is supplemented by useful information regarding engineering institutions, centres of technical training, research bodies, associations of employers and employees, etc.

The volume should form a valuable addition to our annual reference books, and will no doubt fill a long-felt want amongst engineers.

**Industrial Administration (A Series of Lectures). By Messrs. Berriman, Heath, Hill, Johnson, Kent, Legge, Pear and Rowntree.**

London: Messrs. Longmans, Green & Co, 7/6 net.

The scientific organisation of industry which is rapidly altering the point of view from which labour problems are approached has led to the publication of a separate class of literature to which this volume of 195 pages is a welcome and useful addition.

The scope of the work is very wide' and is throughout dealt with by experts in the varying fields of enquiry. During the war the various munition workers' enquiries and reports gave much valuable data, and this, coupled with observations made previous to 1914, and since 1918, has given a basis on which it is possible to construct a preventative scheme which will greatly minimise the ill-health which has been the bane of the industrial system of the past.

Mr. B. Seebohm Rowntree deals with social obligations of industry to labour and calls for a more human relationship between the employer and the employee, and, whilst admitting the difficulty of bridging the gap between the stockholder of the company and the worker in the factory, we feel that the dissemination of the facts he states will help to form a public opinion which will insist upon the provision of the amenities of civilised life for every worker who fulfils his obligation to the nation during the period of reconstruction.

Professor Pear deals with the applications of psychology to industry, and other chapters treat of education as a function of management and training for factory administration.

The elimination of disease is dealt with by Dr. Legge in a lecture on occupational diseases, whilst atmosperic conditions and efficiency, and industrial fatigue are lucidly discussed in two lectures by Dr. Leonard Hill and Dr. Stanley Kent.

The chapter on industrial councils is very interesting, and we would like to see this volume on the shelves of every employer and Trades Union leader.

## MEMORANDUM.

**Forms for Concrete Roads.**—It is of great importance that the tops of the side forms for concrete roads should be kept clean. An engineer recently inspecting some road work in America stated that he found these forms often completely covered with concrete spilled over them, and on this the wheels of the tamping machine travelled with an irregular and jerky motion.

Particles of aggregate were either crushed under the wheels or caused the machine to ride over them, with a perceptible lift. In some places the accumulation was nearly ½ in. thick. Neither the machine operator nor the man in charge of the surfacing and edging paid any attention to this condition, and apparently it was not noticed by the inspector. Patches of this concrete would adhere to the surface of the steel forms, so that when they were shifted ahead and set in place they did not give a true surface, and fresh concrete would add to the obstruction.

# QUESTIONS AND ANSWERS RELATING TO CONCRETE

***In response to a very general request we are re-starting our Questions and Answers page. Readers are cordially invited to send in any questions. These questions will be replied to by an expert, and, as far as possible, they will be answered at once direct and subsequently published in this column for the information of our readers, where they are of sufficient general interest. Readers should supply full name and address, but only initials will be published. Stamped envelopes should be sent for replies.--ED.***

---

*Question.—H. B. W. writes :—*

*As a regular subscriber to this paper, I should be glad if you could kindly answer he following general query with reference to distance pieces for reinforced concrete work.*

*What is the usual practice as to distance pieces between the vertical rods in circular and square columns, and also between the tension rods in beams? Are there any firms who make a speciality of distance pieces, or are they made up out of stiff wire on the job by the contractor ; also, is it usual in the case of circular columns with eight vertical rods, for the helical binding to be tied with wire as it passes each separate rod?*

*Answer.*—It is rather the exception to use distance pieces in reinforced concrete work, since as a general rule the rods can be kept the correct distance apart by wiring them at their inter-sections with the stirrups in the case of beams, or the bindings in the case of columns. In columns it is unusual for the bindings to be more than 9 in. apart, and as these never consist of less than 3/16 in. diameter, and frequently larger rods, it is clear that if the vertical rods are wired to them they will be kept in position during concreting. In the case of concrete beams where the great weight of concrete may press the reinforced rods down so that they nearly touch the bottom mould, the practice is sometimes adopted of preparing small pieces of concrete about 1½ in. sq., and in length the width of the beam, and resting the bottom rods on these so as to ensure suitable cover between the bottom bars and the bottom of the beam. In the case of columns packing pieces are often used between the vertical bars and the sides of the column mould, but these generally consist of small pieces of timber, which are removed as the concreting of the column proceeds. In the case of concrete piles, distance pieces between the longitudinal rods are fairly frequently used so as to ensure the binding being tight against the rods. The distance pieces in this case are often made of cast iron ⅜ in. sq. and about 14 in. long, depending on the size of the pile and provided with a bird's-eye mouth at each end to engage the bar. They are generally placed diagonally across the pile, one across each diagonal being provided about 6 ft. apart. Such distance pieces can be obtained from any firm making cast iron goods, as they are extremely simple to cast.

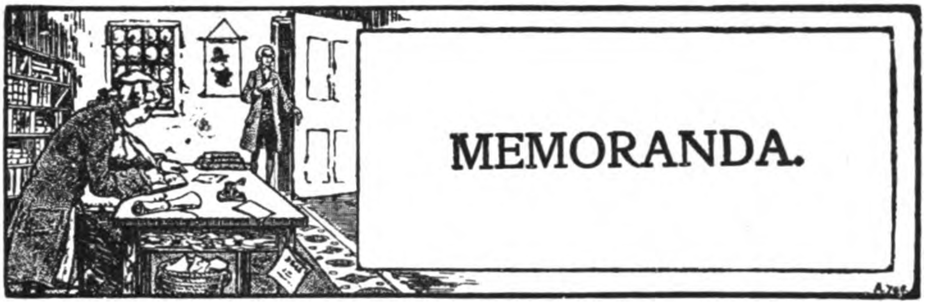
---

## MEMORANDA.

**Reinforced Concrete Quay at Gateshead.**—A new quay is under construction at Gateshead, and is being built on the Hennebique system of reinforced concrete ; it consists of front piles 16 in. square, encased in reinforced concrete cylinders braced to back piles and surmounted by a platform. The structure is built so as to permit of considerable dredging as required by the River Tyne Commissioners. The engineer is Mr. D. Balfour, M.Inst.C.E., and the contractors are Messrs. Binns and Co.

**Concrete for Swimming Baths.**—What is believed to be one of the largest open-air swimming baths in the West of England was recently put into use. It is 120 ft. long, 45 ft. wide, and is constructed of reinforced concrete. The depth of the water varies from 3 ft. 6 in. to 7 ft.

**Revision of Reinforced Concrete Specifications in Canada.**—The Canadian Engineering Standards Association has named a committee to draft a specification for cement and concrete, and it is understood that the Engineering Institute will either adopt the resulting specification or use it as a basis for a new one of its own. In any event, an authoritative specification developed in Canada is likley to make its appearance before many months have passed.—*Canadian Engineer.*



*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Permeability of Concrete.**—Some preliminary tests have been made by the Bureau of Standards, Washington, of a new apparatus for determining the rate of penetration of water through concrete and other permeable materials. The apparatus is so constructed that it is not necessary to mould the test piece in any particular shape, but any slab having one fairly smooth face may be tested. Only a few seconds are required for placing and adjusting the test specimen. This will permit specimens to be cut from walls or other portions of structures for tests. Tests so far made, while more in the nature of a try-out of the apparatus than the materials used, have furnished some rather interesting results.

In the accompanying table the results of tests on samples of building stones from various quarries, as well as on some mortar and concrete specimens, are shown. The specimens varied from 1¼ in. to 2½ in. in thickness, and pressure was applied over an area of 25 sq. in.

| Test Specimen. | Absorption in 24 hours. Per cent. | Thickness. in. | Water Pressure. lb. | Time required for Penetration through wall. |
|---|---|---|---|---|
| Limestone 50 .. .. .. .. | 5·80 | 1⅝ | 60 | 10½ minutes |
| Limestone 7E .. .. .. .. | 3·10 | 1¹⁄₁₆ | 60 | 11 minutes |
| Limestone 8907 .. .. .. | 4·40 | 1⅝ | 60 | 19 minutes |
| Limestone 9C .. .. .. .. | 4·60 | 1⅝ | 60 | 2¾ minutes |
| Limestone 14F .. .. .. .. | 3·81 | 1⅝ | 60 | 20 seconds |
| Limestone 5G .. .. .. .. | 3·48 | 1¼ | 60 | 1½ minutes |
| Sandstone .. .. .. .. | 5·56 | 2½ | 60 | 10 seconds |
| 1 : 6 Portland Cement Mortar .. | 7·8 | 2 | 60 | 3½ hours |
| 1 : 1½ : 2 concrete .. .. .. | 5·8 | 2 | 60 | Did not fail in 24 hours; when broken through water had penetrated only ½ in. |

These results appear to bear out conclusions previously drawn in the Bureau's investigation of the durability of concrete in alkali soils that there is no apparent relation between absorption and permeability.

While considerable work must be done to standardise the method of making the permeability tests, it appears that this apparatus will assist in studying with a minimum of effort an important characteristic of concretes which has in the past been generally ignored, due to lack of suitable apparatus.

**Re-Cast Concrete Pipe for Plunger Pits.**—In a recently completed factory building there were required for some presses 64 plunger pits, each 2 ft. 6 in. inside diameter and 13 ft. deep. For the outer casing of the pits vertically placed precast concrete pipes were sunk in the earth, and a steel casing, containing the press plunger, afterwards put in. In executing the work a hole was excavated approximately 2 in. smaller in diameter than the pipe and carried down a distance of approximately 13 ft. Two or three lengths of pipe were set up in a vertical position over this hole and, guided by a template, were allowed to settle under their own weight as far as they would go. A head-block was then put over the top pipe and by means of a steam hammer the pipe driven to the bottom of the excavation. The excess material which the lower edges of the pipe cut away on its descent was then removed from inside the shaft, and the bottom of the hole was concreted in.

**Concrete Road Foundations in the City.**—In our last month's issue brief reference was mde to the concrete road foundations being laid in Houndsditch and Finsbury Pavement. These have now been completed, and this month we are able to furnish our readers with further particulars of the methods of construction adopted, together with two photographs (*Figs.* 1 and 2) taken while the work was in progress.

The concrete in both instances was 8 in. thick, mixed in the proportion of 4 : 2 : 1, and reinforced with B.R.C. Fabric No. 9.

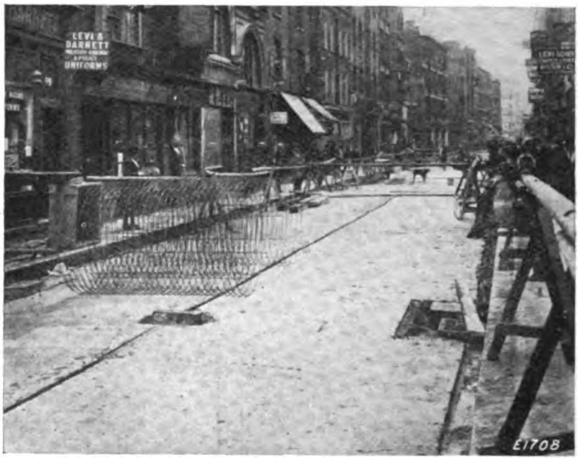


Fig. 1. Road in Houndsditch.

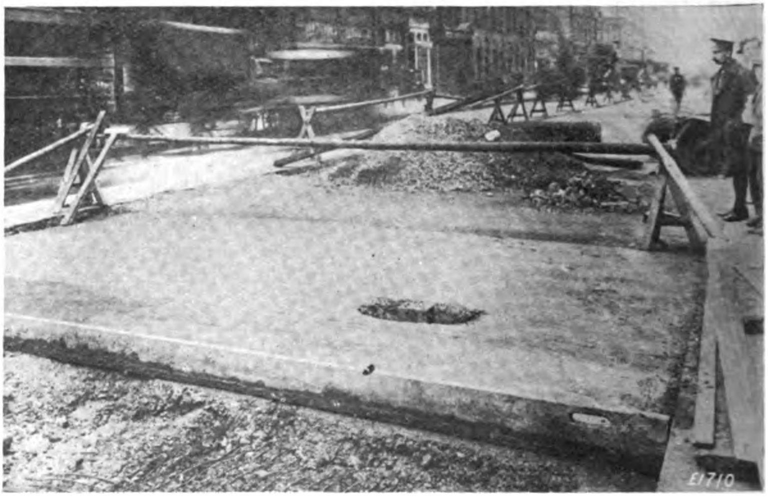


Fig. 2. Road, Finsbury Pavement.

In Houndsditch, which is a narrow thoroughfare, the whole width of the roadway was concreted at one time, but in Finsbury Pavement the work was done in half-widths. In the former case, in order to obtain the correct camber, screeds were fixed down the centre of the road and at both sides; in the latter the screeds were placed in the centre and at one side.

Miller's "Jaeger" mixer was used on both jobs, and in Houndsditch a "Milwaukee" paver, supplied in this country by the Allied Machinery Company, was also employed.

Both roads were surfaced with asphalt. The contractors for the concrete foundation in Houndsditch were Messrs. J. Mowlem and Co., and for the asphalt the Limmer and Trinidad Lake Asphalt Co., Ltd. In Finsbury Pavement the contractors for the complete job were the Val de Travers Asphalt Paving Co., Ltd.

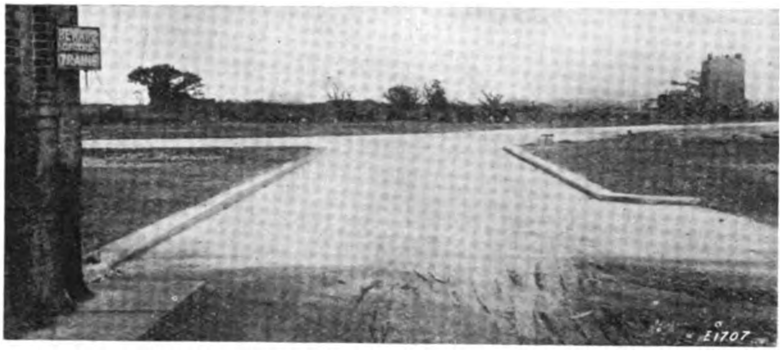


Fig. 3. Road at Hilsea Gas Works

*Fig.* 3 shows a two-course concrete road recently laid for the Hilsea Gasworks The road is 6 in. thick, reinforced with triangle mesh. The contractors were Messrs. P. Croad and Co., Portsmouth.

**Concrete Refrigerators.**—A Philadelphia firm is manufacturing concrete refrigerators with hollow walls. Their construction is shown in the accompanying illustrations. In *Fig.* 1 a metal corner is indicated at 1 ; 2 and 12 mark the enamelled surface . 3 and 11 show the concrete ; 4 and 10 show a dovetailed wooden strip to which the concrete is applied, the strips being attached to an asphalt mastic base, 5 and 9 ; 6 and 8 show fibre board ; 7 is a dead air space. Sectional elevations are shown in *Fig.* 2.—*Concrete, U.S.A.*

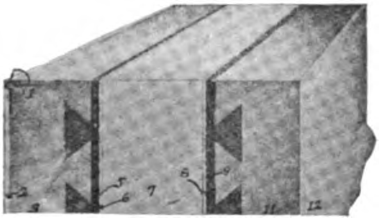


Fig 1. Showing Construction of Refrigerator in detail.

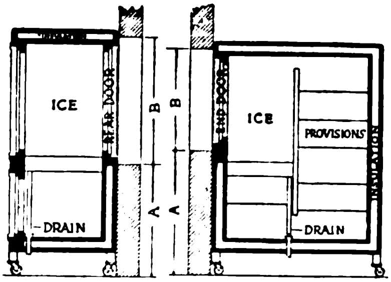


Fig. 2—Sectional Elevation of Concrete Refrigerator

**Reinforced Insulite.**—A new building material is being experimented with in Aberdeen known as reinforced insulite. It is of the concrete type, but differs from the ordinary concrete inasmuch as cork is the principal ingredient used with the cement. The system has been patented, and an experimental house is being erected. The foundations are built of ordinary concrete, and then the steel framework, including beams and cross girders for flooring and roof, are run up. Temporary shuttering is then fitted to the steelwork, and the construction of the insulite wall commences. A point claimed in its favour is the rapidity with which houses can be built of this material, and we are informed the cost compares favourably with either brick, granite or concrete blocks.

**New Building Blocks.**—New building blocks made of sand, lime, cement and charcoal dust are used as substitutes for bricks in the Brest district of France. These blocks sell at £4 10s. the hundred, the size being 10 by 20 by 6 in.—*The Times*.

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## TENDERS ACCEPTED.

### Concrete Houses.

**Barnet.**—The Barnet Urban District Council has received the following tenders for the erection of 33 houses (parlour type) on the Underhill site :—C. Miskin and Co., Ltd., St. Albans, £41,181 18s. 9d. ; E. J. Logan, Holborn, £43,029 (less £100 if in concrete) ; McCormick and Sons, Ltd., London, £46,870 ; Trollope and Colls, London, £40,106 (less £600 if in concrete) ; Royce Cook Construction Co., London, £40,028 1s. (less £1,600 if in concrete). The tenders have been referred to the Housing Commissioner for the District.

**Bodmin.**—The following tenders have been received by the Bodmin Rural District Council for the erection of houses at Nanstallon and Egloshale, and have been referred to the Housing Commission for the area :—Mr. C. F. Ham, of Bodmin—five pairs of Class " A " houses, £1,860 per pair in brick, or £1,180 with nine-inch concrete cavity exterior walls ; Mr. W. E. Bennett, of Bodmin—ten concrete block houses, £937 per house.

**Bury St. Edmunds.**—The Bury St. Edmunds Town Council has awarded a contract for the erection of fifty houses on the " Dorlonco " system of concrete construction to Messrs. Fasey & Son, of Leytonstone.

**Dudley.**—The Dudley Town Council has awarded a contract to Messrs. Tarmac, Ltd., for the erection of concrete block houses, at £1,540 per pair, exclusive of roads, etc.

**Hampton.**—The Hampton Urban District Council has accepted the tender of the Simplex Construction Co., Ltd., at £92,707, for the erection of houses in connection with its housing scheme.

**Ipswich.**—The tender of Messrs. A. Fraser & Son, of London, has been accepted by the Ipswich Town Council for the erection of 100 on the " Dorlonco " steel frame and concrete system on the racecourse site.

**Liverpool.**—The Liverpool Town Council has accepted the tenders of Messrs. G. Calver and Co. for the erection of 20 houses on the " Calver " system of concrete construction ; of Messrs. R. Costain and Son for the erection of 100 houses on the " Duo Slab " concrete system ; and of Messrs. Kirk and Randall, Ltd., for the erection of six houses by special methods of construction.

**Northampton.**—The Housing and Town-planning Committee of the Northampton Corporation has resolved that a further 18 concrete houses, which have been approved by the Housing Commissioner-be included in the contract of the Unit Construction Co., Ltd., making the contract for a total of 118 concrete houses.

### General.

**Bath.**—The Bath Town Council has accepted the tender of Mr. E. Ireland for laying 1,500 superficial yards of reinforced concrete road surface in Lower Bristol Road, at £1 0s. 6d. per yd.

**Bradford.**—The Bradford Town Council has accepted the tender of Messrs. G. and H. Sugden for the construction of a reinforced concrete tank of 80,000 cu. ft. capacity at the sewage works for the sum of £5,200.

**Dundee.**—A contract for a large ferro-concrete gas holder tank for the Dundee Corporation has been awarded to Messrs. K. Holst & Co., of Westminster.

**Hull.**—The Hull Corporation has accepted the tender of Messrs. Hill & Ward, of Hull, for the erection of a workshop and garage (51 ft. by 37 ft.) in ferro concrete, for £2,797.

**Southend-on-Sea.**—The Southend-on-Sea Corporation has accepted the tender of the Gunite Construction Co. for the erection of a school clinic, at the cost of £2,760.

## TENDERS INVITED.

**Dewsbury.**—For the construction of precipitation tanks, etc., at the sewage disposal works, for the Corporation. Sending-in day, November 22nd. Specification, quantities, and form of tender from Messrs. J. Diggle and Son, 14, Brown Street, Manchester. Deposit, £3 3s.

**Esquimault (British Columbia).**—For the construction of a dry dock, for the Department of Public Works, Ottawa. Sending-in day, December 9th. Specification and form of tender from Inquiry Office, Department of Overseas Trade, 35, Old Queen Street, S.W.1.

**Ghent.**—For the construction of two reinforced concrete warehouses for the Municipal Authority. Sending-in day, November 13th. Further particulars from the Inquiry Office, Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

**Saffron Walden.**—For the erection of 33 " B " type houses for the Corporation. Alternative methods of construction approved by the Ministry of Health will be considered. Sending-in day, November 12th. Drawings and specifications, etc., from the Borough Surveyor (Mr. A. H. Forbes), Hill Street, Saffron Walden. Deposit, £1 1s.

**West Hartlepool.**—Supply of materials, including concrete kerbstones, flags, etc., to the West Hartlepool Corporation for the year ended December 31st, 1921. Sending-in day, November 24th. Specification and form of tender from the Borough Surveyor, Municipal Buildings, West Hartlepool.

**Ystrad Mynach and Pengam.**—For the construction of the second section of the new road between from Ystrad Mynach to Pengam (Hengoed to Tir-y-berth), one mile in length. Sending-in day, November 15th. Specification and quantities from Council Offices, Hengoed, Glam.

## TRADE NOTES.

**" Campistron " Straightening Machine.**—Our attention has been called to this machine, which, we understand, is extensively used in France by reinforced concrete contractors for straightening mild steel rounds up to ⅝-in. diameter. It consists of three parts—namely, a reel to carry the coils, the straightening machine, which can be worked by hand or, if necessary, by motors, and shears for cutting the bars to the required lengths. The sole agents in this country are the Helical Bar and Engineering Co., Ltd., 1, Victoria Street, Westminster, S.W.1, from whom further particulars can be obtained.

### PERSONAL.

Professor E. R. Matthews, Assoc.M.Inst.,C.E., F.R.S.E., F.R.San.I., has been appointed Chief Sanitary Engineer to H.M. Office of Works, and will serve under the Director of Works—Sir Frank Baines, C.B.E., M.V.O.

### NEW COMPANIES REGISTERED.

Mastics, Ltd. (170,199). Registered September 13th. Dealers and manufacturers of asphalte and cement. Nominal capital, £1,000 in 1,000 8 per cent. 10s. preferred ordinary shares and 1,000 7 per cent. 10s. management shares. Directors to be appointed by subscribers—remuneration, £150 each; chairman, £200. Subscribers: H. J. Heygat, 32, Dawson Place, W.2, and J. Cimelli, 5, Wharton Street, W.C.1.

Breeze Slabs (Liverpool), Ltd. (170,432). Registered September 25th. The Temple, Dale Street, Liverpool. Breeze slab manufacturers. Nominal capital, £2,000 in 2,000 £1 shares. Directors: H. H. Bates, 24, Selbourne Street, Liverpool; F. A. J. Paulson, Exchange Hotel, Liverpool; and C. A. Watson, Victoria Road, Waterloo, Liverpool. Qualification, one share; remuneration to be voted.

Skipton Syndicate, Ltd. (170,527). Registered September 29th. 17, Tower Royal, E.C.4. Manufacturers and dealers in cement, plaster, etc. Nominal capital, £20,000 in 20,000 £1 shares. Directors: A. N. Dillon, Burton Lodge, Steeple Aston, Oxford; and H. W. Holland, O.B.E. Remuneration to be voted at general meeting.

### RECENT PATENT APPLICATIONS.

113,283.—H. Cockel: Floor beams of reinforced concrete.

149,732.—G. P. Campbell: Building blocks.

149,743.—D. McIntyre: Building blocks and tiles.

150,033.—G. C. Thomas: Concrete block, brick and slab-making machines.

150,369.—H. P. Brown: Concrete mixing and placing plant.

150,386.—D. G. Comyn and T. Lea: Reinforced concrete building construction.

150,433.—J. M. Jardine: Reinforced concrete floors.

150,439.—W. Alban Richards and Co., and E. L. R. Grimsley: Building blocks.

150,451.—Improved Twisted Steel Bar Co., H. K. Dyson and A. W. C. Schelff: System of reinforced concrete construction

150,462.—H. A. Hamilton and E. J. Twigg: Concrete blocks.

150,476.—F. J. Judd: Concrete wall and beam construction.

150,565 and 150,566.—A. Young: Machines for making concrete blocks.

150,590.—A. S. Adams: Fixing *in situ* building blocks and slabs.

150,764.—M. J. Dawson: Ferro-concrete floors and ceilings.

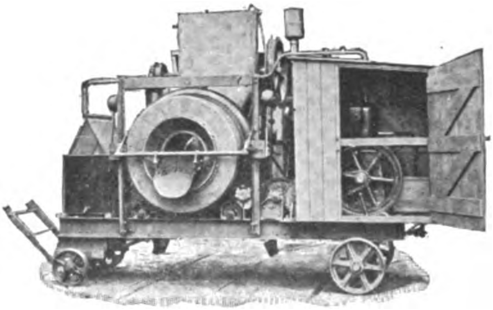
150,834.—A. C. Knipe: Hollow building blocks.

150,880.—A. T. J. Gueritte and L. G. Mouchel and Partners: Reinforced concrete.

150,921.—W. H. Worthington, Ltd., and W. Wild: Methods for centring concrete construction.

151,049.—A. M. A. Struben: Construction of buildings.

151,182.—T. Makin: Shuttering for concrete building construction.



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# CONCRETE AND CONSTRUCTIONAL ENGINEERING

**DECEMBER 1920 VOL. XV. No. 12**

*A MONTHLY JOURNAL for Engineers, Architects, Surveyors and Contractors and all interested in Cement, Concrete, Reinforced Concrete, Fire-Resisting Construction and Structural Steel.*

## CONTENTS,

**Editorials.**

**New Reinforced Concrete Mill at Heckmondwike.**
**Coke Bunkers for the Northampton Gas Light Company.**

**Maximum Stresses in Short Circular Columns of Masonry, Eccentrically Loaded.**
By R. E. STRADLING, M.C., B.Sc., etc., Lecturer in Civil Engineering, University of Birmingham.

**Concrete Cottage Building.**
**Cottages at Brockley.**

**Concrete Road Construction.**
**Abergavenny and Brecon Main Road, South Wales. Longhoughton Road, Northumberland.**

**Concreting in Cold Weather.**

**Recent British Patents Relating to Concrete.**

**Concrete in Theory and Practice.**
**Reinforced Concrete Simply Explained.**
By OSCAR FABER, O.B.E., D.Sc.

**Cement Notes.**

**Test of a Concrete Floor Arch. New Methods of Construction.**

**New Concrete Machinery.**

**New Books.**

**Correspondence.**

**Memoranda.**

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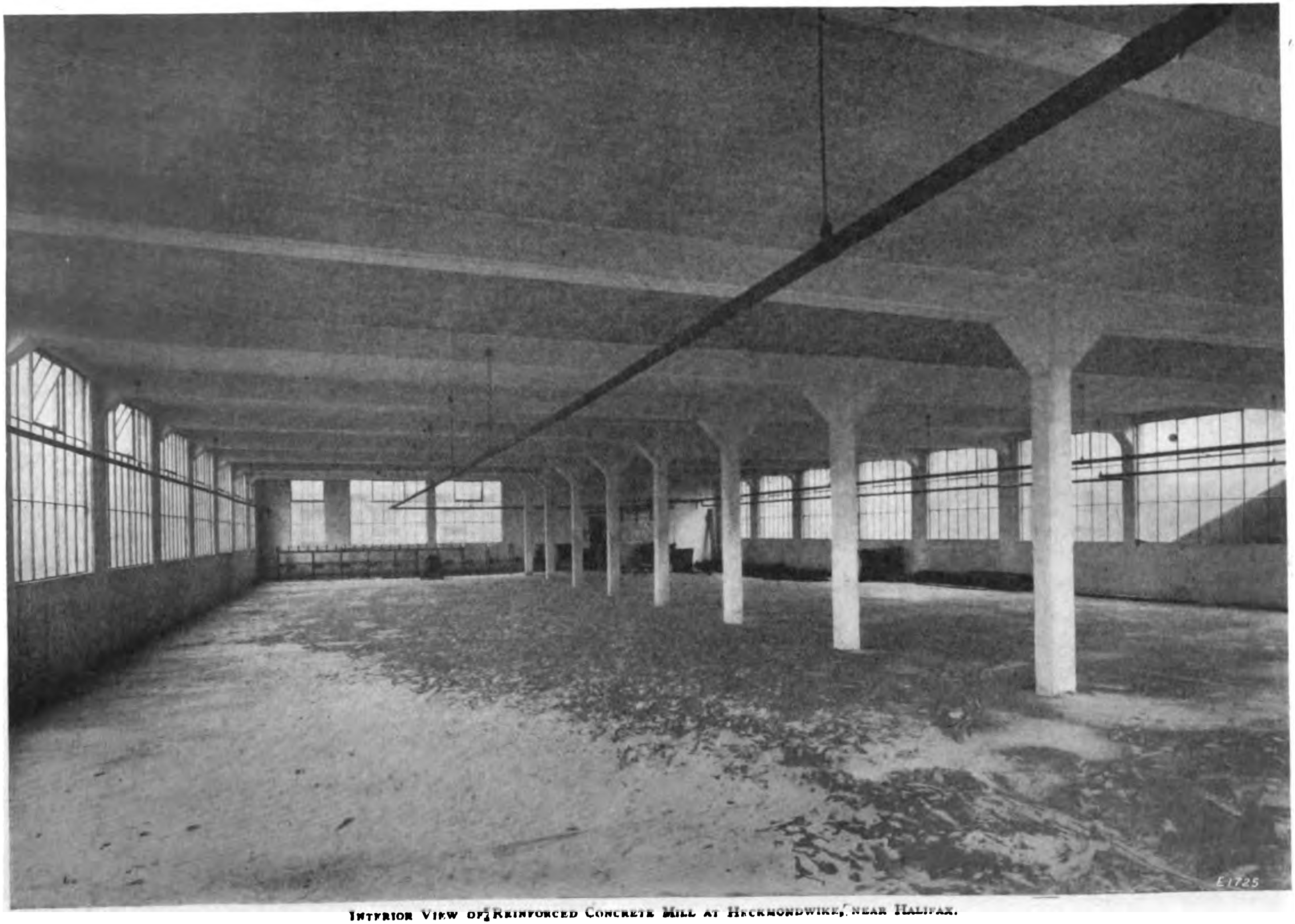

INTERIOR VIEW OF REINFORCED CONCRETE MILL AT HECKMONDWIKE, NEAR HALIFAX.

*(For description see page 789).*

# CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume XV. No. 12. LONDON, DECEMBER, 1920.

## *EDITORIAL NOTES.*

### INDUSTRIAL RESEARCH.

WE have received a copy of the report, just issued, of the Committee of the Privy Council for Industrial Research. The year reviewed has been marked by numerous activities, and though there are many pressing scientific problems relative to concrete industries which yet await consideration, the scope of the Department is so much widened that we may hope for more researches of specific interest to our readers at a not too distant future. The formation of a Building Research Board which has been long under consideration is now accomplished. Mr. H. O. Weller, who has had large engineering experience in India, is Director and we look forward to the publication of his programme. There are a great many problems connected with cements and limes needing solution, and it is not too much to ask that these problems shall be given special prominence.

The Department has now taken over both the National Physical Laboratory and the Geological Survey Museum, institutions of standing and importance which should do much to strengthen its position. Numerous Research Associations have been formed, or are in course of formation, in connection with various industries, and while these are supported by trading bodies at least some of the results they achieve may be expected to benefit the public as well as the parties interested. Another sphere of activity to which importance should be attached is the collection of existing data on research problems and the prevention of overlapping by ensuring the due exchange of information. The Department thus aspires to play the rôle of a clearing house for industrial research, and the development of this work should meet with every encouragement.

### ROAD DEVELOPMENT.

THE large schemes now under consideration for the construction of new roads offer a unique opportunity for experiments with the use of modern road-making machinery which, so far, has not been taken up in this country as much as it might have been. The Minister of Labour has stated that twenty-five road schemes are about to commence shortly, and the London County Council and the Middlesex County Council have approved schemes to cost nearly half-a-million pounds each. To urge the adoption of labour-saving machinery on these schemes, which have primarily been formulated to relieve unemployment, would seem to defeat the object in view, namely, to find work for as many as possible, but the limit to the number employed will be decided by the amount of money allocated to the work, and there is no reason why the output of the men, whatever the number, should not be as large as possible. Such machinery—scarifiers, concrete mixers and pavers, elevators, screeding and tamping machines, etc.—have been used and found successful in America for many years past, and are now being manufactured by many firms in this country. Their value was proved in the recent reconstruction of Oxford Street, where it is stated the use of concrete mixers and pavers alone effected a saving in cost from 15 to 20 per cent. per square yard compared with the occasion of the previous rebuilding when the mixing and placing was done by hand. The machinery also reduced the amount of labour required by three-fourths, but if under the new schemes the number of men to be employed could turn out four times as much work with the aid of machinery, surely it is in the interests of the rate and tax-payers, who have to foot the bill, that they should be given the opportunity to do so. The burden of the rates is now so great that the utmost possible value should be received for money spent in the relief of unemployment, and the use of machinery in road making is one direction in which this desirable end may be attained.

### THE TIME FACTOR IN ROAD MAKING.

OBJECTIONS to concrete roads are frequently expressed by local authorities and others on account of the time they have to remain unused whilst the concrete is hardening, but what is one to think of this objection when a really important thoroughfare such as Oxford Street is closed to traffic for a period of two months or more whilst new foundations are put in and a wood block surface laid ? We know the work was held up for a day or two owing to a strike, but that such a busy artery has been allowed to be entirely closed to through traffic for such a length of time would seem to indicate that the question of time does not carry much weight with those in authority. As a matter of fact, when deep foundations have to be renewed a road can be finished ready for traffic quite as quickly if it is built simply as a concrete-surface road ; in any case the concrete has to be given time to mature, and the extra time required to lay wood blocks or asphalte is eliminated.

# TWO EXAMPLES OF RECENT REINFORCED CONCRETE CONSTRUCTION.

## NEW REINFORCED CONCRETE MILL AT HECKMONDWIKE.

Reinforced concrete construction is particularly well suited to the erection of mills, and there is undoubtedly a growing tendency to adopt this comparatively new material instead of the older methods of construction, which are now becoming obsolete, local stone and bricks being five times pre-war cost.

The illustrations (*Frontispiece* and *Fig.* 1) show a large new four-storey woollen mill which has been recently completed at Heckmondwike, near Halifax, for Messrs. T. F. Firth & Sons, Ltd.

The entire structure, including the walls, was carried out on the Coignet System of reinforced concrete, in accordance with the requirements and under the supervision of Mr. Joseph F. Walsh, F.S.I., Architect, of Halifax.

The methods of calculation and the rules approved by the Royal Institute of British Architects were specified for the construction of this building.

The specification called for finishing the concrete off the boards throughout. The inside to have two coats of limewash and the outside surfaces to be dressed and filled and left with natural cement face. The angles of all beams, columns, piers, etc. to be splayed or rounded off. The floors of the various passages, landings, conveniences and thresholds to be finished with ¾ in. granolithic paving. The rain water heads are also of moulded concrete.

The flat roofs and domes were finished with 1½ in. thick pudloed cement, composed of 1¾ parts of ¼ in. granite chippings, ¾ parts granite dust and 1 part of cement with 5 lb. of Pudlo to each 100 lb. of cement.

The proportions of the materials for the general concrete work were specified to be 1–2–4, and ordinary mild steel round bars were adopted for the whole of the reinforcement.

The balder bed for the ground floor has been made 6 in. thick and finished 6–1 with 4 in. thick concrete. All the mill floors were finished with "Sano" jointless composition flooring of light natural colour, with coved angles to walls and piers. Each floor of the mill and the gangways were calculated for a safely distributed load of 2 cwts. per square foot with a factor of safety of 4.

The ceiling under the flat roof of the mill and the inside of the domes were underdrawn with plaster ceiling slabs, fixed with a 2 in. cavity below underside of concrete roofs, by means of Terrawode fixing blocks embedded into underside of concrete.

All the shafting hangers, brackets for electric wiring, steam, etc. are fixed direct to the reinforced concrete.

The window sills throughout were made in moulded concrete, weathered and throated, with return end 3 in. thick jointed in cement.

The general external dimensions of the building are 61 ft. wide by 108 ft. 6 in. long and about 62 ft. high.

All the floors were practically identical, which, of course, facilitated the construction to a great extent. The width of the building was divided into two by a central row of pillars supporting principal beams having scantlings of 24 in. by 12 in. and supporting 6 in. slabs without any secondary beams.

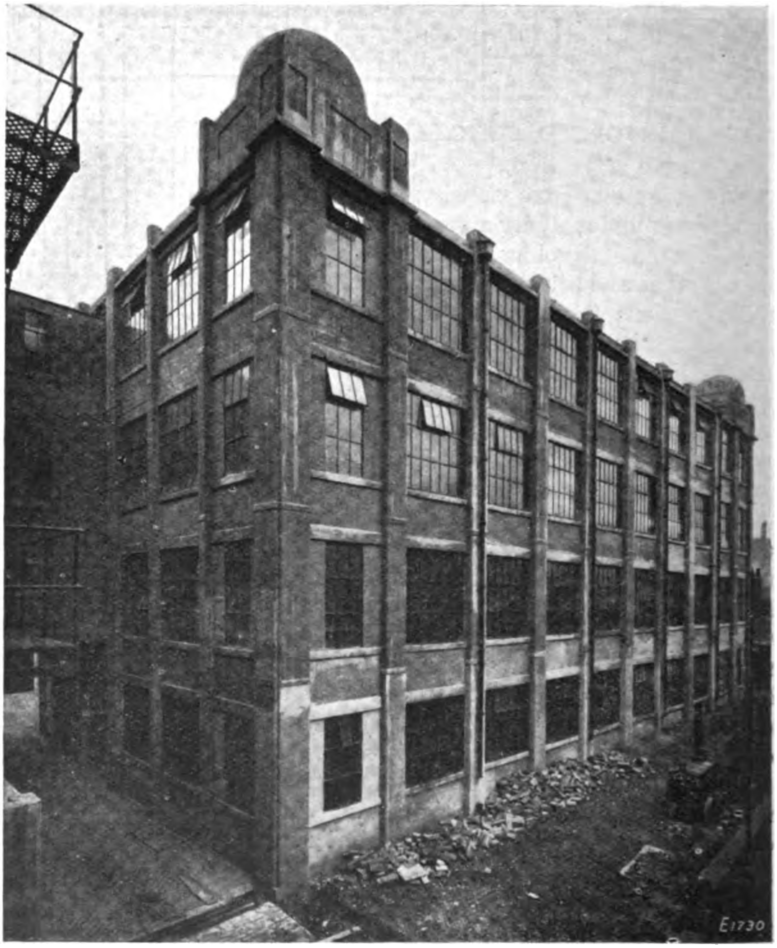

Fig. 1. Exterior View of Building.

The reinforcement of the pillars was composed of eight vertical bars joined together by small spiral ties.

The reinforcement of the beams was composed of two groups of bent bars, in accordance with the Coignet System.

The reinforcement of the slabs and walls was, as usual, composed of a meshwork of bars.

The whole of the work was executed by Messrs. Henry Atkinson & Sons, Ltd., of Leeds.

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## COKE BUNKERS FOR THE NORTHAMPTON GAS-LIGHT COMPANY.

Reinforced concrete coke hoppers are now being largely used throughout the country by Gas Companies. They offer the obvious advantage under existing circumstances of being cheaper than steel bunkers and less liable to deterioration from the acid fumes which are inevitable in all gas-works.

*Fig.* 2. shows a row of bunkers recently constructed on the Coignet System for the Northampton Gas-Light Company. The work was executed in accordance with the general plans and requirements of Mr. George S. Eunson, Engineer of the Gas Company.

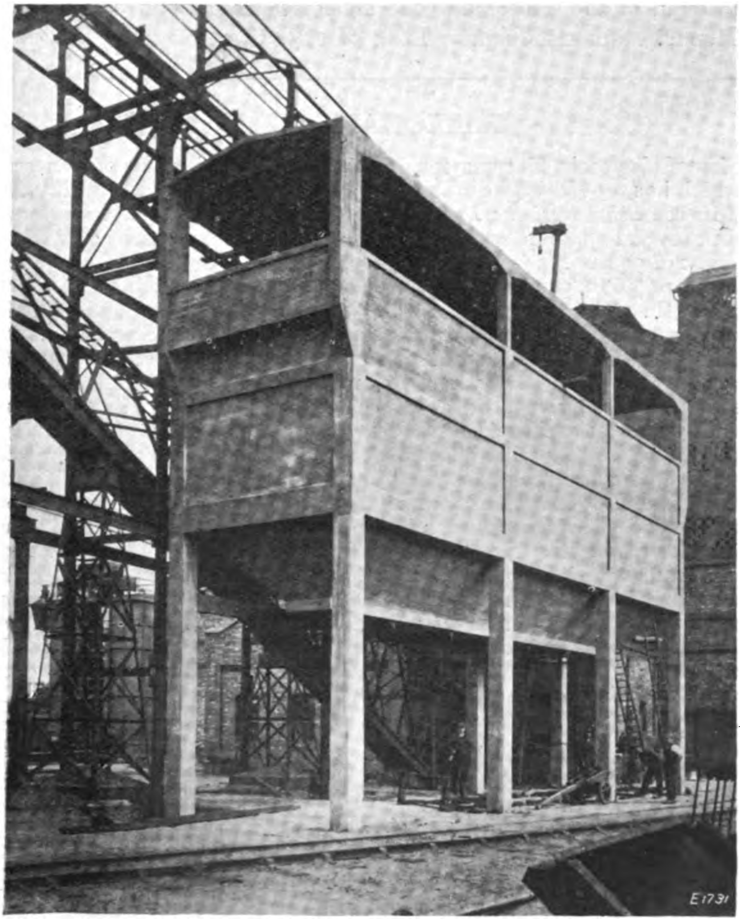

Fig. 2. Bunkers for the Northampton Gas-Light Company.

The general dimensions of these bunkers are about 40 ft. in height and about 56 ft. in length, by 13 ft. in width.

The coke is delivered from a conveyor to a chute discharging into two rotary screens, each of which is inclined towards the end of the bunkers. The coke is gradually distributed through holes ⅜ in., 1 in., 2½ in., and the larger pieces fall into the end bunkers, in such a manner that the coke falls into four separate compartments. The bottom of the hoppers is provided with sliding doors operated by chains and levers which can be worked from the ground level.

In order to shelter the machinery and the men working on the top of the bunkers, a reinforced concrete roof has been provided, also side walls to prevent the wind from driving the dust from underneath the screen plant.

The whole of the reinforcement consists of round bars of mild steel and, as shown in the illustration, the work has been carried out in such a way as to leave a good finished surface.

The Contractors for the reinforced concrete construction were Messrs. Walter Jones & Sons, of Westminster.

The design of the reinforced concrete for both these structures was carried out by Messrs. Edmond Coignet, Ltd., of 125, Gower Street, London, W.C. 1.

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## MEMORANDUM.

**Reinforced Concrete Sleepers for Light Railways.**—A type of concrete railway sleeper, which has proved very durable on the Weiz-Birkfeld light railway, in Styria, is described in the *Schweizerische Bauzeitung*. The type of sleeper resembles a French pattern, but several apparently successful modifications have been adopted. The rails have a height of 90 mm. (3 9/16 in.), the flange is 75 mm. (3 in.) wide, and the weight is 18 kg. per metre (36 lb. per yard); thirteen sleepers are required for a rail 9 m. (nearly 30 ft.) in length. The armouring of the concrete consists of four iron rods running horizontally and longitudinally, one pair near the top, the other near the bottom of the sleeper, and a fifth intermediate rod. The rods have a diameter of 12 mm. (½ in.) and are cross-connected by twisted wires, which impart considerable strength to the iron frame, while it is being embedded in the concrete. In moulding the sleeper, two longitudinal grooves are formed in the lower surface to give the gravel a grip on the sleeper. Four holes are further left for the wooden blocks into which the spikes are to be driven; holes for the spikes, or screws, are first drilled in the wood, and the neck of the wooden block is encircled by an iron ring. An iron plate is interposed between the rail flange and the sleeper surface. No spikes have worked loose during the nine years of service of the sleepers, and no other trouble has arisen, although some of the sleepers and rails were laid and put under load after the concrete had been allowed to set for not more than fourteen days; this short period was purposely chosen. Small cracks, mostly in the direction of the rails, did form in some cases, but sleepers affected were not removed, nor repaired, and have proved as strong as the others. The sleepers weigh 120 kg. each, three times as much as the wooden sleepers, and the cost was twice as great. The additional cost is considered to be justified by the durability of the sleepers.

# MAXIMUM STRESSES IN SHORT CIRCULAR COLUMNS OF MASONRY, ECCENTRICALLY LOADED.

By **R. E. STRADLING, M.C., B.Sc., A.M.I.C.E., A.M. Am. Soc. C.E.** (Lecturer in Civil Engineering, University of Birmingham).

THE case under consideration is that of a circular column, say of granite or other stone whose length is short compared with its diameter, and where the stress distribution across the base can be considered as that due to a uniform direct stress plus that due to a couple $P.h$ [where $P$ is the load and $h$ its distance from the Neutral axis of the column]. It is assumed that the type of construction used cannot take tensile stress at right angles to horizontal planes through the column.

Let $P$ = vertical load on column.

$h$ = horizontal distance between line of action of $P$ and vertical through centre of gravity of cross section of column under consideration.

$A_1$ = area of cross section of radius $r = \pi r^2$.

$I_{GG}$ = Moment of Inertia of cross section about a horizontal line through centre of gravity.

$K^2 = \frac{I_{GG}}{A_1}$

$f$ and $f^1$ = stress at outer edge of column as shown in *Fig.* 1.

$$\text{Then } f = \frac{P}{A_1}\left[1 + \frac{hr}{k^2}\right] \quad \dots\dots\dots \quad (1)$$

$$\text{and } f^1 = \frac{P}{A_1}\left[1 - \frac{hr}{k^2}\right] \quad \dots\dots\dots \quad (2)$$

Now from (2) $f^1$ becomes zero when $k^2 = hr$

$$\text{i.e. } h = \frac{k^2}{r} = \frac{r}{4}$$

This means then that if $h$ exceeds $\frac{r}{4}$, then if the material can withstand tensile stresses $f^1$ will be tensile.

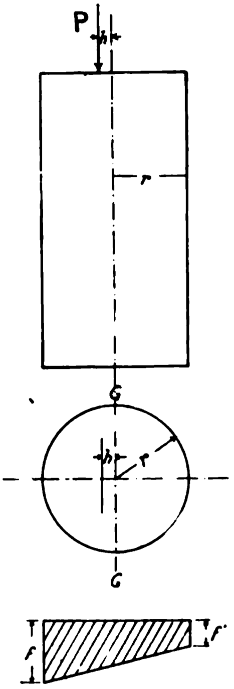


Fig. 1.

In the case of a granite pillar as usually used in building construction, the various blocks are simply placed one on the other with the smallest possible thickness of mortar or cement between to form a bed. This cannot be assumed to withstand tension.

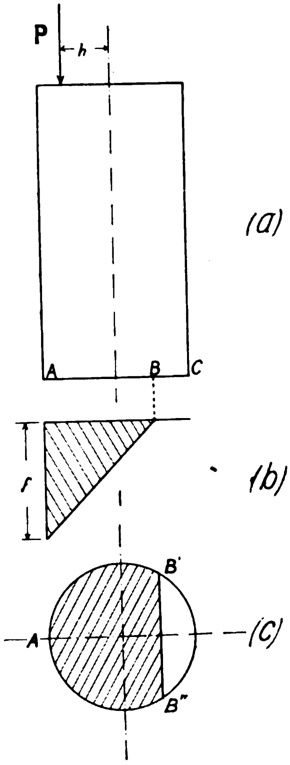


Fig. 2.

Hence the cross section under consideration may be taken as adjusting itself until a distribution of stress somewhat as shown in *Fig.* 2 (*b*) takes place. The area represented by *AB* in *Fig.* 2 (*a*) is the only portion taking the load. The area referred to is the shaded one in *Fig.* 2 (*c*) lettered *A′*, *B′*, *B″*.

The following investigation is an attempt to find this area and then the maximum stress occurring ($f$).

Let $a$ = distance from centre of circular cross section to point of zero stress (Point *B* in *Fig.* 2*a*).

$\bar{x}$ = distance between centre of circular section and centre of gravity of segment of circle shaded in *Fig.* 3.

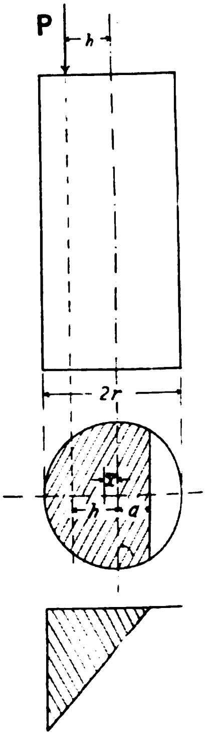


Fig. 3.

Taking axes of coordinates as shown in *Fig.* 4,

$I_{YY}$ = Mom. of Inertia of segment about $YY$.
$I_{GG}$ = ,, ,, ,, ,, $GG$.
$A$ = area of segment

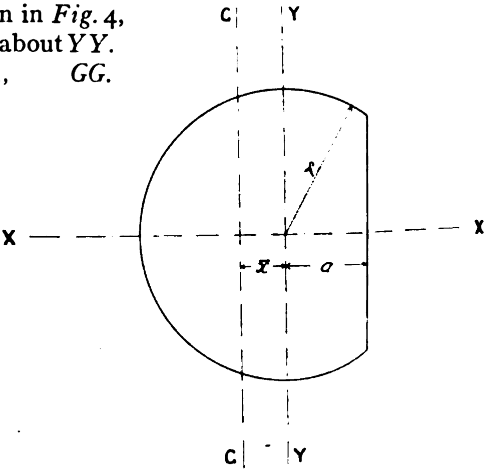


Fig. 4.

Then

$$A = \pi r^2 - \int_a^r 2y\,dx \quad . \quad . \quad . \quad (1)$$

$$A\bar{x} = \int_a^{-r} 2yx\,dx \quad . \quad . \quad . \quad . \quad (2)$$

$$I_{YY} = \int_a^{-r} 2yx^2\,dx \quad . \quad . \quad . \quad . \quad (3)$$

$$I_{GG} = I_{YY} - A\bar{x}^2 \quad . \quad . \quad . \quad . \quad (4)$$

$$k^2 = f_1 = \frac{P}{A} \quad \frac{I_{GG}}{A}.$$

Then

$$f^1 = f_1\left[1 - \frac{ed_Y}{k^2}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where

$e$ =eccentricity of load $P$ on segment $=h-\bar{x}$

and

$d_r=a+\bar{x}$

also

$$f=f_1\left[1+\frac{ed_c}{k^2}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where $d_o=r-\bar{x}$.

In (1)—(3) let $y=r\sin\theta$

$x=r\cos\theta$

where $\theta=$ angle between radius to point $(x, y)$ and axis $O, X$.

Then $dx=-r\sin\theta d\theta$.

Then (1) becomes

$$A=\pi r^2-2\int_{\cos^{-1}\cdot\frac{a}{r}}^{o} -r^2\sin^2\theta d\theta$$

$$=\pi r^2-r^2\int_{\cos^{-1}\cdot\frac{a}{r}}^{o} (\cos 2\theta-1)d\theta$$

$$=\pi r^2-r^2\left[\frac{\sin 2\theta}{2}-\theta\right]_{\cos^{-1}\cdot\frac{a}{r}}^{o}$$

i.e. $$A=\pi r^2-r^2\cos^{-1}\cdot\frac{a}{r}+a\sqrt{r^2-a^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Also (2) becomes

$$A\bar{x}=2\int_{\cos^{-1}\cdot\frac{a}{r}}^{\pi} -r^3\sin^2\theta\cos\theta d\theta$$

$$=2r^3\left[-\frac{\sin^3\theta}{3}\right]_{\cos^{-1}\cdot\frac{a}{r}}^{\pi}$$

i.e. $$A\bar{x}=\frac{2}{3}(r^2-a^2)\sqrt{r^2-a^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Also (3) becomes

$$I_{YY}=2\int_{\cos^{-1}\cdot\frac{a}{r}}^{\pi} -r^4\sin^2\theta\cos^2\theta d\theta$$

$$=-2r^4\int_{\cos^{-1}\cdot\frac{a}{r}}^{\pi}\left[\frac{1-\cos 4\theta}{8}\right]d\theta$$

$$=\frac{-r^4}{4}\Big[\theta-\tfrac{1}{4}\sin 4\theta\Big]_{\cos^{-1}.\frac{a}{r}}^{\pi}$$

$$=\frac{-r^4}{4}\Big[\pi-\cos^{-1}.\frac{a}{r}+\frac{a}{r^4}(2a^2-r^2)\sqrt{r^2-a^2}\Big]\ .$$

Since $\frac{r^4\pi}{4}$ is the moment of inertia of a circle about a diameter, and the moment of inertia of a segment about the same axis must be less,

$\therefore$ The bracketed portion of this expression must be $+ve$.

Hence the $-ve$ sign outside may be dropped.

It is due to the order in which the limits have been taken, i.e.

$$I_{rr}=\frac{r^4}{4}\Big[\pi-\cos^{-1}.\frac{a}{r}+\frac{a}{r^4}\ (2a^2-r^2)\sqrt{r^2-a^2}\Big]\quad\dots\dots\dots\quad(9)$$

Let $\qquad a=nr$ where $n$ varies between 1 and $-1$.

Then (7) becomes $\underline{A=r^2[\pi-\cos^{-1}n+n\sqrt{1-n^2}]}\quad\dots\dots\dots\dots\quad(10)$

(8) $\quad$ ,, $\quad\underline{A\bar{x}=\frac{2}{3}r^3(1-n^2)\sqrt{1-n^2}}\quad\dots\dots\dots\dots\quad(11)$

and (9) $\quad$ ,, $\quad\underline{I_{rr}=\frac{r^4}{4}[\pi-\cos^{-1}n+n(2n^2-1)\sqrt{1-n^2}]}\quad\dots\dots\quad(12)$

From (5) $f^1=f_1\Big[1-\frac{ed_r}{k^2}\Big]$

If $f^1=$zero at some point $nr$ from centre of circle,

then $\qquad k^2=ed_r$

i.e. $\qquad \frac{I_{aa}}{A}=(h-\bar{x})\ (a+\bar{x})$

or $\qquad I_{aa}=A(h-\bar{x})\ (a+\bar{x})$

i.e. $\qquad I_{rr}-A\bar{x}^2=Aha+Ah\bar{x}-Aa\bar{x}-A\bar{x}^2$

$$I_{rr}=Aha+A\bar{x}(h-a)\quad\dots\dots\dots\dots\dots\quad(13)$$

Substituting values of these from (10), (11) and (12), and putting $a=nr$, we get

$$\therefore\ \frac{r^4}{4}[\pi+n(2n^2-1)\sqrt{1-n^2}-\cos^{-1}n]=r^2[\pi-\cos^{-1}n+n\sqrt{1-n^2}]nh+\tfrac{2}{3}r^3(1-n^2)\sqrt{1-n^2}(h-nr)$$

i.e. $\frac{r}{4}[\pi+n(2n^2-1)\sqrt{1-n^2}-\cos^{-1}n]=h[n(\pi-\cos^{-1}n+n\sqrt{1-n^2})+\tfrac{2}{3}(1-n^2)\sqrt{1-n^2}]-\tfrac{2}{3}r.n.(1-n^2)\sqrt{1-n^2}$

which reduces to

$$\frac{r}{4}\Big[\pi+n\frac{\sqrt{1-n^2}}{3}(5-2n^2)-\cos^{-1}n\Big]=h\Big[n\pi-n\cos^{-1}n+\frac{\sqrt{1-n^2}}{3}(n^2+2)\Big]$$

or $$\frac{h}{r}=\frac{1}{4}\cdot\frac{\left[(\pi-\cos^{-1}n)+n\frac{\sqrt{1-n^2}}{3}(5-2n^2)\right]}{\left[n(\pi-\cos^{-1}n)+\frac{\sqrt{1-n^2}}{3}(n^2+2)\right]} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (14)$$

The writer has now given successive values to $n$ between 1 and $-1$ and plotted $\frac{h}{r}$ against $n$.

The table for this is shown on page 798 and the curve on page 799. This enables $n$ to be found for any value required between $\frac{h}{r}=\cdot25$ and $\frac{h}{r}=1$.

The application of this is shown by the following example which occurred in the writer's work, and to get a solution of which the above was worked out.

A granite column carried a dead load ($W$) plus a small side thrust ($T$) due to an arch whose springing was at the top of the column as shown diagrammatically in *Fig.* 5.

Combining these by the parallelogram of forces, the resultant cut the base at a point 3½″ from the centre. The diameter at base was 16½″, and thus the above case was produced where $P$=vertical component of this resultant acting at a distance $h=3\frac{1}{2}''$ from centre. $P=32$ tons.

This assumes, of course, that the horizontal component can be resisted by the frictional forces set up at the joint.

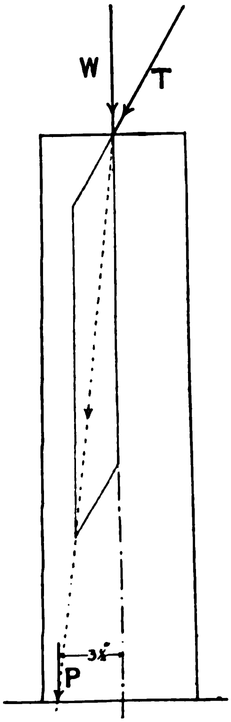


Fig. 5.

*Example*— $r=8\cdot25''$ $h=3\cdot5''$

$$\therefore \frac{h}{r}=\frac{3\cdot5}{8\cdot25}=\underline{\cdot424} \text{ approx.}$$

From curve (1) on page 799

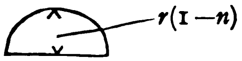
"$n$"$=\cdot44$

hence we have now to calculate

$A$, $\bar{x}$, $I_{rr}$ and $I_{oo}$.

*A*. This is best obtained by the "Area of Segments" table given in Chambers' *Mathematical Tables* in the following manner:—

$$A=\frac{\pi}{4}d^2-c_1d^2$$



$$=d^2(\cdot7854-\cdot18)$$

$$=\frac{d}{2}(1-n)$$

$$=d\times\cdot28$$

$$=\cdot6054\times(16\cdot5)^2$$

$$=\underline{164\cdot8} \text{ sq. ins.}$$

$\therefore$ From tables for $\cdot28d$

$c_1=\cdot18$

$\bar{x}$ is obtained from equation $\overline{(11)}$ and $A$.

$$A\bar{x}=\frac{2}{3}\left(\frac{16\cdot5}{2}\right)^3(1-n^2)\sqrt{1-n^2}$$

$$=\frac{2}{3}\times\frac{(16\cdot5)^3}{4\times2}\times\cdot8064\times\cdot8979$$

| I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI | XVII | XVIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $n$ | $\cos^{-1} n$ | $\pi-\cos^{-1} n$ | $n(\pi-\cos^{-1} n)$ | $n^2$ | $1-n^2$ | $\sqrt{1-n^2}$ | $\frac{\sqrt{1-n^2}}{3}$ | $n^2+2$ | $2n^2$ | $5-2n^2$ | VIII × XI | $n$ × XII | VIII × IX | III + XIII | IV + XIV | XV ÷ XVI | XVII ÷ 4 $\left(\frac{h}{r}\right)$ |
| 1 0 | 0 | 3 1416 | 3 1416 | 1·0 | 0 | 0 | 0 | 2 0 | 20 | 3 0 | 0 | 0 | 0 | 3 1416 | 3 1416 | 1 0 | 25 |
| ·9 | 4510 | 2 6906 | 2 4215 | ·81 | 19 | ·4359 | ·1453 | 2 8100 | 1 62 | 3 38 | ·491 | 4419 | ·408 | 3 133 | 2 830 | 1 106 | ·277 |
| 8 | ·6439 | 2 4982 | 1 9966 | ·64 | 36 | ·6000 | ·2000 | 2 6400 | 1 28 | 3 72 | 744 | 5·952 | 528 | 3083 | 2 527 | 1 22 | 305 |
| ·7 | 7954 | 2 3462 | 16923 | 49 | ·51 | 7142 | ·2381 | 2 4900 | 98 | 4 02 | ·957 | 6699 | ·593 | 3016 | 2 235 | 1 353 | 338 |
| ·6 | ·9274 | 2 2142 | 13285 | ·36 | 64 | ·8000 | ·2667 | 2 3600 | ·72 | 4 28 | 1141 | ·6896 | 629 | 2899 | 1 958 | 1·48 | ·37 |
| ·5 | 1·0472 | 2 0944 | 1 0472 | ·25 | 75 | ·8661 | 2887 | 2 2500 | 50 | 4 50 | 1299 | 6495 | ·6 50 | 2 744 | 1·697 | 1·616 | ·404 |
| ·4 | 11592 | 1 9824 | 7930 | ·16 | 84 | ·9165 | ·3055 | 2 1600 | 32 | 4 68 | 1·430 | ·5720 | ·660 | 2 554 | 1 453 | 1·756 | ·439 |
| ·3 | 1266 | 1876 | 563 | 09 | 91 | ·954 | 318 | 2·09 | ·18 | 482 | 1533 | ·4599 | 6645 | 2 3359 | 1 2275 | 1·9 | ·475 |
| ·2 | 1 37 | 1772 | 354 | 04 | ·96 | 98 | ·327 | 2 04 | ·08 | 4 92 | 1 609 | 3218 | 667 | 2 094 | 1 021 | 2 05 | ·512 |
| ·1 | 1·47 | 1 672 | 167 | ·01 | ·99 | ·995 | ·332 | 2·01 | ·02 | 4 98 | 1·653 | ·1653 | 667 | 1 837 | ·834 | 2·202 | ·55 |
| 0 | 1571 | 1·571 | 0 | 0 | 1 | 1 0 | ·3333 | 2·0 | 0 | 5 0 | 1.665 | 0 | 667 | 1 571 | ·667 | 2 36 | 59 |
| −·1 | 1672 | 1 47 | −·147 | 01 | 99 | 995 | ·332 | 2 01 | 02 | 4 98 | 1 653 | −·1653 | ·667 | 1 305 | ·520 | 2·51 | ·63 |
| −·2 | 1772 | 1·37 | −·274 | 04 | 96 | 98 | ·327 | 2·04 | ·08 | 4 92 | 1609 | −·3218 | ·667 | 1·048 | 393 | 2·67 | ·67 |
| −·3 | 1876 | 1 266 | −·3798 | 09 | ·91 | 954 | 318 | 2·09 | 18 | 4 82 | 1 533 | −·4599 | 665 | 806 | ·285 | 2·83 | ·71 |
| −·4 | 1 9824 | 1 1592 | −·4637 | 16 | 84 | ·9165 | 3055 | 2·16 | 32 | 4 68 | 1 430 | −·5720 | 660 | ·587 | 196 | 2 99 | ·75 |
| −·5 | 2 0944 | 1 0472 | −·5235 | ·25 | 75 | ·8661 | ·2887 | 2 25 | ·50 | 4 50 | 1·299 | −·6495 | ·650 | 398 | ·126 | 3·16 | ·79 |
| −·6 | 2 2142 | ·9274 | −·5564 | 36 | ·64 | 80 | 2667 | 2·36 | ·72 | 4 28 | 1 141 | −·6896 | ·629 | 243 | 073 | 3·33 | ·832 |
| −·7 | 2 3462 | 7954 | −·5568 | ·49 | 51 | ·7142 | 2381 | 2·49 | ·98 | 4 02 | ·0572 | −·6700 | ·5909 | ·1259 | ·036 | 3·473 | ·868 |
| −·8 | 2 4982 | 6439 | −·5147 | 64 | 36 | ·60 | 2000 | 2·64 | 1·28 | 3 72 | ·744 | −·5952 | 528 | ·0482 | ·0133 | 3·622 | ·905 |
| −·9 | 2 6906 | ·4510 | −·4059 | ·81 | ·19 | ·4359 | ·1453 | 2 81 | 1 62 | 3 38 | ·491 | −·4420 | ·4083 | ·009 | ·0024 | 3·75 | 9375 |
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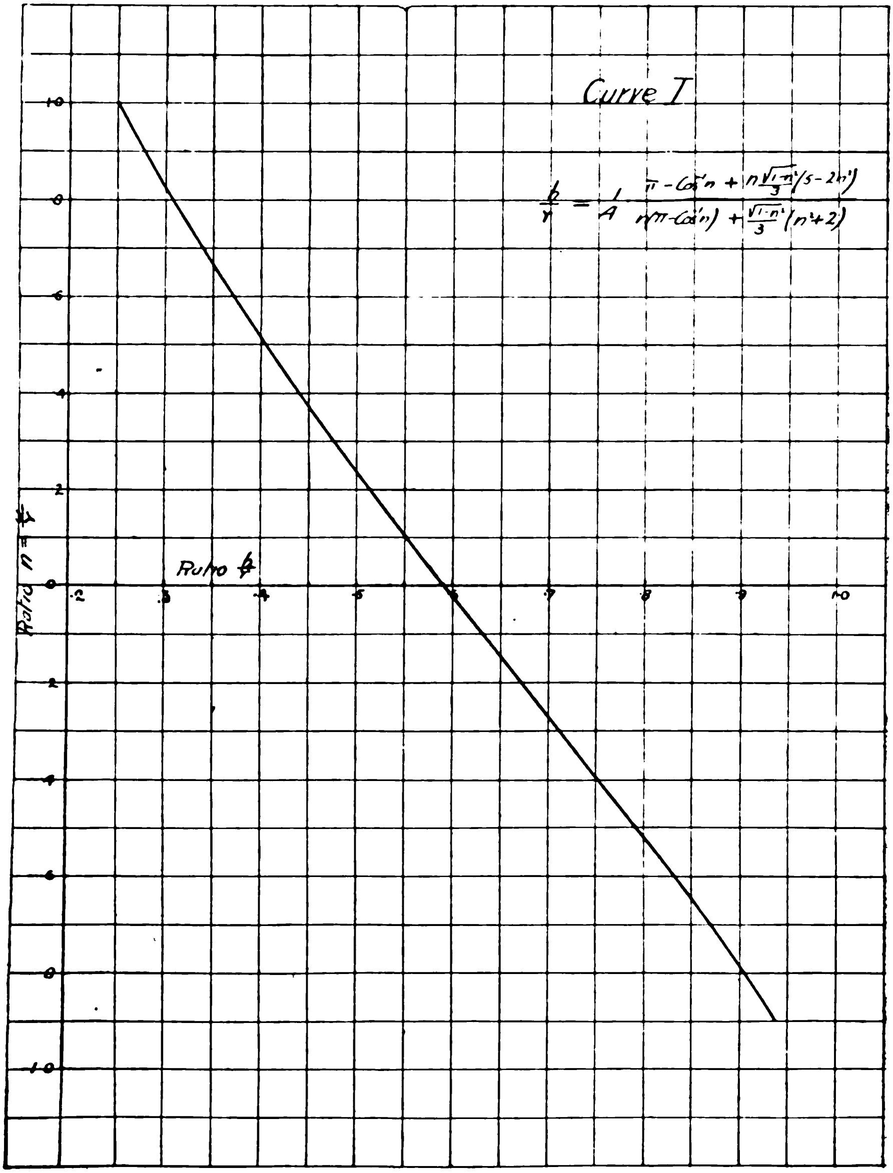

Curve I
$\frac{b}{r} = \frac{1}{A} \cdot \frac{\pi - \cos^{-1} n + n\frac{\sqrt{1-n^2}}{3}(5-2n^2)}{n(\pi-\cos^{-1} n) + \frac{\sqrt{1-n^2}}{3}(n^2+2)}$
Ratio $\frac{b}{r}$
Ratio n
10
8
6
4
2
0
2
4
6
8
10
·2
·3
·4
·5
·6
·7
·8
·9
1·0

CURVE I.

or

$$\bar{x}=\frac{16{\cdot}5^3\times{\cdot}8064\times{\cdot}8976}{12\times{\cdot}6054\times(16{\cdot}5)^2}$$
$$=\underline{1{\cdot}644''}$$

$$I_{rr}=\frac{(8{\cdot}25)^4}{4}[3{\cdot}1416-{\cdot}44\times{\cdot}8976\times{\cdot}6128-1{\cdot}1151]$$
$$=\frac{(8{\cdot}25)^4}{4}\times1{\cdot}7843=\underline{2066}\text{ ins.}^4$$

$$A\bar{x}^2=164{\cdot}8\times(1{\cdot}644)^2$$
$$=\underline{443{\cdot}2}\text{ ins.}^4$$

$$\therefore I_{gg}=2066-443=\underline{1623}$$

$$\therefore k^2=\frac{I_{gg}}{A}=\frac{1623}{164{\cdot}8}=\underline{9{\cdot}847}$$

$$e=h-\bar{x}=3{\cdot}5-1{\cdot}64=\underline{1{\cdot}86}$$
$$d_c=r-\bar{x}=8{\cdot}25-1{\cdot}64=\underline{6{\cdot}61}$$

$$\therefore f=\frac{32\times144}{164{\cdot}8}\left[1+\frac{1{\cdot}86\times6{\cdot}61}{9{\cdot}847}\right]\quad\text{(From equation (6))}$$
$$=\frac{2{\cdot}25\times32\times144}{164{\cdot}8}$$
$$=\underline{63\text{ tons}}/\square'.$$

This method, though probably the more accurate, is long, and to facilitate calculations other curves have been plotted from which the values of this maximum stress can be calculated very quickly and simply. These curves have been obtained in the following manner :—

From equation (6)

$$f=f_1\left[1+\frac{ed_c}{k^2}\right]\quad\ldots\ldots\ldots\ldots\ldots\quad(6)$$

where $f$=max. stress at edge of column.

$f_1=\frac{W}{A}$ (where $W$=load on column and $A$ = area of segment).

$e=h-\bar{x}$

$d_c=r-\bar{x}$

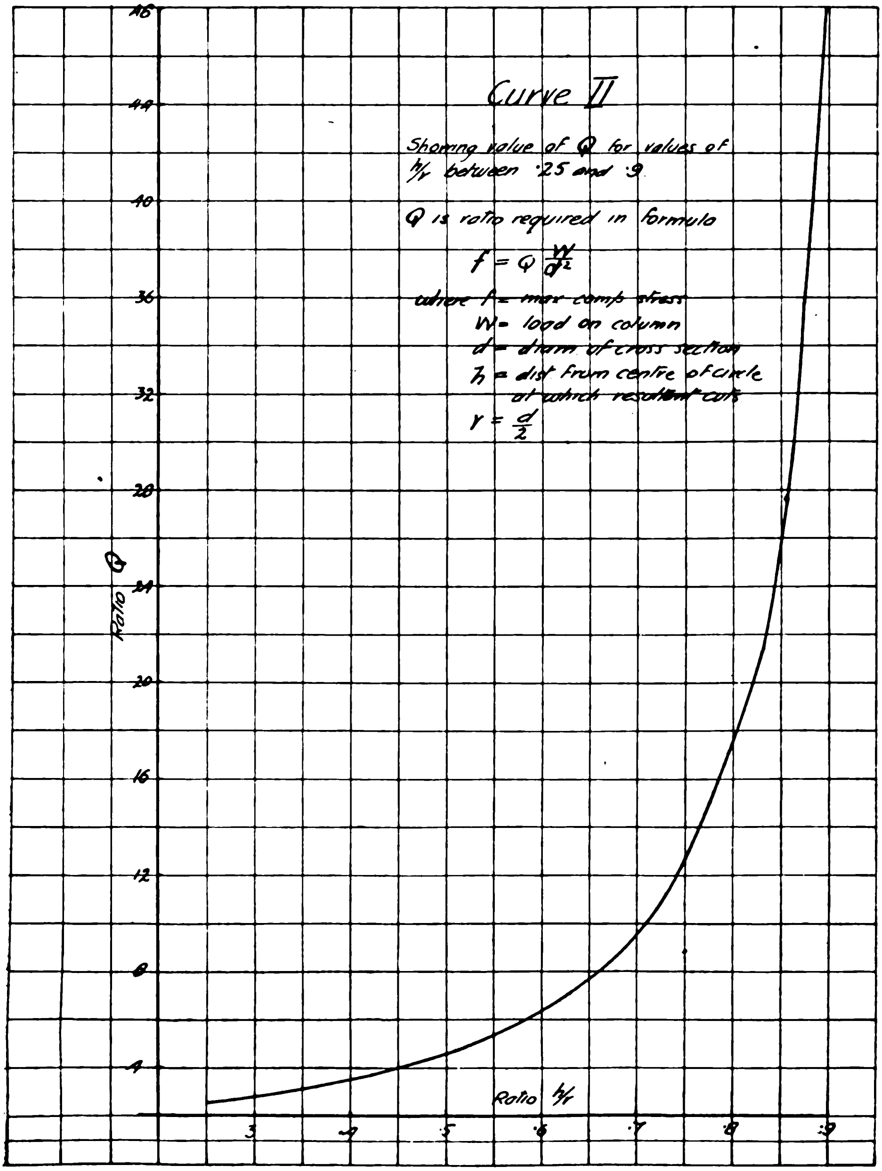
$k^2=\frac{I_{gg}}{A}$

All these symbols can be expressed in terms of $n$, and hence from Curve I. in terms of $\frac{h}{r}$, the actual expression known in a practical case.

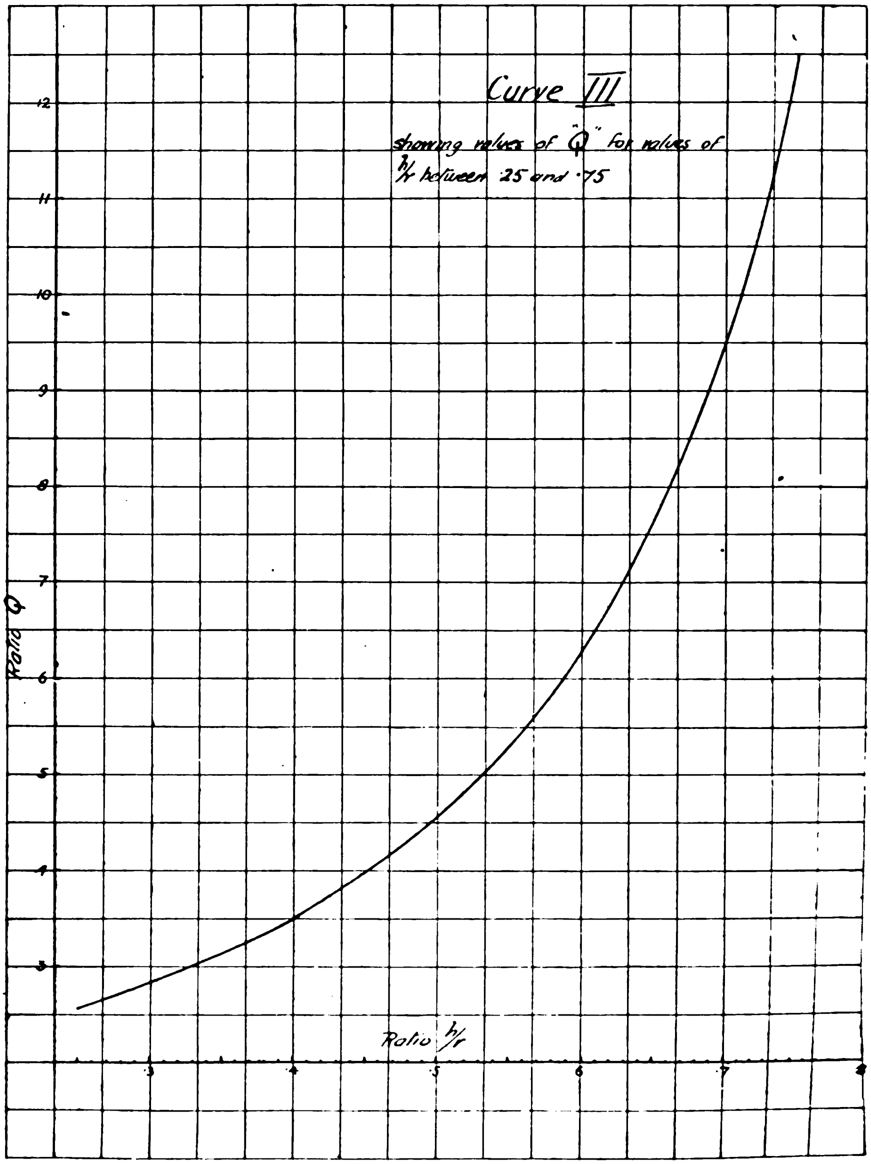
From equation (10) $A=xr^2$ where $x=[\pi-\cos^{-1}n+n\sqrt{1-n^2}]$.

" " (11) $Ax=yr^3$ where $y=\frac{2}{3}(1-n^2)\sqrt{1-n^2}$.

Hence $\bar{x}=\frac{y}{x}r$.


Curve II
Showing value of Q for values of
h/r between ·25 and ·9
Q is ratio required in formula
$f = Q\frac{W}{d^2}$
where f = max comp stress
W = load on column
d = diam of cross section
h = dist from centre of circle
at which resultant cuts
$r = \frac{d}{2}$
Ratio Q
Ratio h/r
48
44
40
36
32
28
24
20
16
12
8
4
·3
·4
·5
·6
·7
·8
·9

CURVE II.


Curve III
showing values of "Q" for values of h/r between ·25 and ·75
12
11
10
9
8
7
6
5
4
3
Ratio Q
Ratio h/r
·3
·4
·5
·6
·7
·8

CURVE III.

Also from equation (12) $I_{YY}=zr^4$ where $z=\frac{1}{4}[\pi-\cos^{-1}n+n(2n^2-1)\sqrt{1-n^2}]$.

Hence $k^2=\frac{I_{GG}}{A}=\frac{I_{YY}-A\bar{x}^2}{A}$

$$=\frac{zr^4-\frac{y^2}{x}r^4}{xr^2}=\left(\frac{z}{x}-\frac{y^2}{x^2}\right)r^2.$$

Hence equation (6) may be written—

$$f=\frac{W}{xr^2}\left[1+\frac{\left(h-\frac{y}{x}r\right)\left(r-\frac{y}{x}r\right)}{\left(\frac{z}{x}-\frac{y^2}{x^2}\right)r^2}\right]$$

$$=\frac{W}{d^2}\cdot\frac{4}{x}\left[1+\frac{\left(\frac{h}{r}-\frac{y}{x}\right)\left(1-\frac{y}{x}\right)}{\left(\frac{z}{x}-\frac{y^2}{x^2}\right)}\right]$$

and this may be written as

$$f=Q\cdot\frac{W}{d^2} \quad \ldots\ldots\ldots\ldots\ldots \quad (14)$$

Where $Q$ is a coefficient depending upon the value of $\frac{h}{r}$ and $d$=diameter of column at section considered.

The variation of $Q$ with $\frac{h}{r}$ can be plotted by giving successive values to $n$ in the expressions for $x$, $y$ and $z$ and calculating from these the value of $Q$. This has been done, and the resulting curve plotted in Curve II.

To obtain more accurate reading within probable working limits, the portion of the curve between $\frac{h}{r}=\cdot25$ and $\frac{h}{r}=\cdot75$ has been replotted to a larger scale in Curve III.

To show the use of this curve, the application to the example previously worked out follows,

$$\frac{h}{r}=\cdot424.$$

Hence from Curve III. $Q=3\cdot72$.

$$\therefore\ f=3\cdot72\frac{W}{d^2}$$

$$=\frac{3\cdot72\times32\times144}{(16\cdot5)^2}\text{ tons }/\square'$$

$$=63\text{ tons }/\square'.$$

Such examples often occur in practice, and it is hoped these curves will be of assistance to designers.

# THE CONCRETE INSTITUTE.

## MONTHLY NOTES.

By the SECRETARY

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### COUNCIL AND COMMITTEE MEETINGS FOR DECEMBER AND JANUARY.

| | |
|---|---|
| 1920 | |
| December 2nd | R.C. Practice Standing Committee, at 4 p.m.<br>Science Standing Committee, at 5.30 p.m. |
| „ 8th | Finance and General Purposes Committee, at 5.30 p.m. |
| „ 15th | Literature Standing Committee, at 5.30 p.m. |
| „ 16th | Council, at 5.30 p.m. |
| „ 16th | Ordinary General Meeting, at 7.30 p.m. Paper by Mr. H. J. Deane entitled "Special applications of R.C. in Docks with specific reference to the R.C. Gates at Tilbury Docks." (Lantern.) |
| 1921 | |
| January 6th | R.C. Practice Standing Committee, at 4 p.m.<br>Science Standing Committee, at 5.30 p.m. |
| „ 13th | Literature Standing Committee, at 5.30 p.m. |
| „ 13th | Ordinary General Meeting, at 7.30 p.m. Paper by Mr. H. Kempton Dyson, entitled "Tests on High Tensile Steels." (Lantern.) |
| „ 20th | Finance and General Purposes Committee, at 5.30 p.m. |
| „ 27th | Council, at 5.30 p.m. |
| „ 27th | Ordinary General Meeting, at 7.30 p.m. Paper by Mr. J. A. Howe, B.Sc., F.G.S., entitled "Geology in relation to building stones." (Lantern.) |

### CONCRETE AGGREGATES (*continued*).*

(22) **Cornwall.**—The felspar obtained from the refuse heaps of china clay washings is contaminated with clay, thus making it unsuitable for first-class Concrete. (R.C.B.) ‡

(23) **Crowborough (Sussex).**—(*a*) Sand rock containing 95 per cent. of silica. (*b*) Ironstone of the following composition:

$SiO_2$ = 40·62 per cent.
$Al_2O_3$ = 0·34 per cent.
$Fe_2O_3$ = 49·76 per cent.
$CaO$ = 1·34 per cent.
$MgO$ = a trace
$SO_3$ = a trace (R.C.B.)

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* See issues commencing with August, 1920.

‡ Items marked R.C.B. are from information furnished by Mr. R. C. Branston and kindly forwarded by the British P.C. Manufacturers, Limited.

(24) **Denbigh.**—
*General description :* Limestone.
*Source and locality :* The Graig Quarry, near Denbigh.
*How obtained :* Raised in quarry : Chippings and dust from Roadstone.
*Is available quantity limited ?* No.
*Transport facilities :* Railway siding and Road, up to quarry.
*Is there any provision at or near source for crushing ?* Crusher in quarry.
*Kind of stone or coarse material :* Limestone.
*Kind of sand or fine material :* Fine red sand can be obtained from a place near Prodfari.
*Size of particle :* ¼ in., ½ in., ¾ in. and dust.
*Remarks :* Screened.

(25) **Derbyshire.**—"There is very little dug gravel in the county, and the local stone available is limestone, basalt, gritstone and furnace slag. A certain amount of river gravel is obtainable in the south of the county. The Leicestershire Granite Quarries serve the southern portion of the county, and the Welsh quarries are available for the north-western portion."

(26) **Doncaster.**—Badly graded gravel, dirty and too flat. (R.C.B.) At Bawtry, Doncaster, there are gravel and sand containing 25 per cent. loam. (R.C.B.)

(27) **Downpatrick.**—" In inland parts of this county the aggregate most used for concrete work is 1½ in. to 2 in. gauge freshly quarried Silurian Grit, which is found practically over the greater part of the county, the screenings being used as sand. South of a line drawn roughly between Newcastle and Newry, granite of good quality is available.

Adjoining the coast from Bangor to Warrenpoint, shingle and sand from the beach are largely and successfully used for aggregate for concrete.

From the bed of the Upper Bann, which rises in the Mourne mountains and flows through Katesbridge, Banbridge to Lough Neagh, in some places river gravel and sand of good quality are obtained."

(28) **Dudley (Worcestershire).**—Black slag containing 19 per cent. sulphur. Other slags containing sulphide and calcium sulphate. Also coal bat or clinker is used, which is, however, very deficient in strength. (R.C.B.)

(29) **Dungeness (Kent).**—Gravel obtainable ; it discolours water and probably contains organic matter. (R.C.B.)

(30) **Easthampstead R.D.C. (Berkshire).**—
*General description :* Three local gravel pits.
*Source and locality :* Easthampstead and Sandhurst.
*How obtained :* Digging.
*From whom obtained :* Various estates upon a Royalty basis.
*Is available quantity limited ?* No.
*Present maximum output per day :* 60 cub. yards.
*Transport facilities :* Carts and motor lorries.
*Is there any provision at or near source for washing or crushing ?* No.
*Price per cub. yd., and where delivered :* 3s. to 4s. at the Pit.
*Is composition uniform ?* No.
*Kind of stone or coarse material :* Flint and sandstone.
*Kind of sand or fine material :* Of little use.
*Relative proportions of coarse and fine material :* Varies (1 to 3).
*Shape of particles :* Rounded.
*Size of particles :* 3 in. down to $\frac{1}{30}$ in.
*Impurities present :* Clay and organic matter.
*General remarks :* Very little used for concrete faced work.

(31) **Elgin (or Moray) County.**—
*General description :* River and pit gravel.
*Source and locality :* River Spey, Lossie, Findhorn, and many pits in many parts of the county.
*How obtained :* Digging, and wheeling out with barrows.
*Is available quantity limited ?* Not appreciably.
*Present maximum output per day :* Six cub. yards.
*Transport facilities :* Cartage to Railway stations or Harbours.
*Is there any provision at or near source for washing or crushing ?* } Washing and crushing are not required.
*Price per cubic yard :* 5s. to 10s.
*Kind of stone or coarse material :* Gravel of mixed stone, including granite quartzite ; all hard.
*Kind of sand or fine material :* Millions of tons of pure sands obtainable.
*Relative proportions of coarse and fine material :* Varies at different places.
*Shape of particles :* Rounded.
*Size of particles : approximate percentage that needs crushing to pass ¾ in. screen.* } Any size may be had by screening. About one-half.
*Impurities :* None.
*Weight per cub. ft. dry :* 19 cub. feet per ton.

(32) **Ely, Isle of (North Cambridgeshire).**—
*General description :* Gravel and sand.
*Source and locality :* Whittlesey.
*How obtained :* Digging.
*Is available quantity limited ?* Yes.
*Present maximum output per day :* One hundred tons.
*Transport facilities :* Rail.
*Is there any provision at or near source for washing or crushing ?* No.
*Price per ton, and where delivered :* 1s. 6d. per ton at Pits.
*Relative proportions of coarse and fine materials :* Proportion of coarse very small.
*Shape of particles :* Angular.

## THE PRESIDENTIAL ADDRESS.

THE opening meeting of the 1920–21 Session of the Concrete Institute was held on Thursday, November 25th, when Mr. E. Fiander Etchells delivered his Presidential address, in which he dealt briefly with the progress of Science and Engineering, and also with the affairs of the Institute during the past year. Touching upon the question of Scientific Research, the President referred to the desire of inventors to prevent the results of many years' investigation from being taken up by others in order to serve their own interests, and he expressed his sympathy with them. If the State were to finance all research and recompense all inventors the position might be different, but the State had not been kind to science, and even now the funds at the disposal of the Council for Scientific and Industrial Research were utterly inadequate for our national needs. Politicians might discuss various measures for the relief of unemployment and increase in production, but if science were liberally endowed, and if vested interests of one kind and another adopted scientific methods to a greater degree, the increase in production of every commodity would follow.

### CAUSES OF POSITION IN BUILDING INDUSTRY.

In connection with the building industry, the speaker said that hollow bricks had been used in America during the past few years to an increasing extent, and the tendency to use this form of construction in this country was now manifesting itself, but perhaps a more interesting aspect was modern concrete block work, which was a branch of technology or applied science which was only in its infancy. He would like to deal with the fundamental principles of this comparatively new branch.. These were bound up with the present difficulties in regard to housing, which, if dealt with on common-sense principles, should allow of the use of materials and methods of construction which should not be judged by the standards which might not be suitable for the future. At the same time, the majority of builders were beginning to recognize that we were now building for a time and not for eternity, and that we were also building against time. This changed outlook, combined with the high cost of materials, was making us look more kindly on materials which might be regarded by some as of a temporary character. So far as the general building position was concerned, he believed it was due less to the War than to the passing of the Finance Act of 1909, which carried with it secondary, subsidiary and indirect effects which had not been foreseen at the time that Act was introduced. Such so-called democratic legislation was only possible because the great weakness of democracy in practice was that the public was so easily fooled by phrases and was so ignorant of the real facts. False theories in the construction of a railway bridge brought disaster of a more or less limited character, but false theories in political economy could bring disaster to a State, or destruction to a Commonwealth. The pre-war speculative builder erected houses which were sold at a little above the cost price, and the builder or speculator made his profit on the land. That may or may not have been a very anti-social thing, but the Finance Act of 1909 stopped it being done. There was a sudden cessation of building after that Act, builders went out of business, and artisans, who in consequence found themselves out of employment, went into other occupations. That was clearly shown by the number of bricklayers and joiners available as between 1909, when the Finance Act was passed, and 1914. In 1909 there were 116,000 bricklayers in the country, but in 1914 this figure had fallen to 74,000. In 1909 there were 265,000 joiners, and in 1914 the number was only 126,000. It would be seen that these figures had no relation to the War.

### CONCRETE BLOCK CONSTRUCTION.

In dealing with the development of concrete block construction, the speaker dealt with its possibilities and also called attention to some of the earlier unfortunate experiences in the use of concrete blocks. In a considerable number of houses built with concrete blocks the wet drove through the walls, and in some instances the blocks were so porous as to make the houses unfit for habitation, but this was not to decry concrete block construction in itself. It was evidence of ignorance on the part of those who made the blocks, because, if no attempt was made to fill up the voids in the shingle, for instance, it could not be expected that the concrete would be watertight. Also in many houses erected a few years ago there was a great tendency to vertical cracks, not only through the joints but across the blocks themselves, which made it impossible to keep a dry interior. These defects, however, were being overcome. A principal cause of cracking in concrete buildings, especially in houses, was poor foundations, but there was a preponderating percentage of straight-line cracks in cottages built of concrete blocks due to contraction and expansion under temperature changes. When a cottage was put up in the summer time under the conditions he had mentioned there was bound to be contraction, and stresses would be set up in the concrete. These stresses would necessarily be very much greater at certain points than others, and cracks would result. The provision of meshed reinforcement across the places most likely to crack would be useful, but in any case it was desirable to use only matured blocks. If they followed the information in the manufacturers' catalogues, which sometimes said that the blocks could be used after four days, they deserved to have trouble.

### CONCRETE BLOCK MANUFACTURE.

After enumerating in detail the advantages of concrete blocks and some of the essential points to be remembered in connection with their use, Mr. Etchells touched on the question of their manufacture.—He said that with regard to the manufacture of blocks with Portland cement there were four principal methods of ensuring that moisture would not penetrate to the interior of the buildings; the first depended upon the use of a continuous cavity or air gap, the inner and outer sides of the wall being connected with ties of suitable material. The second depended upon the use of a sheet of impervious material, such as bitumen, or even steel plate. In this method the sheets of impervious material were laid and lapped between the inner and outer leaves of the wall, and suitable metal ties were used. The third depended upon the use of some waterproofing compound being mixed with the concrete. The fourth depended upon the use of dense concrete made of impervious materials without voids, it being considered that concrete itself is a water-resisting material.

The water-resisting properties of concrete varied immensely. He had seen instances of water pouring through 30 inches of brick and ballast concrete short of sand, and through 15 feet of concrete in a dam. On the other hand, he had seen specimens of concrete, less than 1 inch in thickness, perfectly dry when used in walls of cisterns. The question of using additional cement or patent compounds in order to ensure water-tightness was, after all, a matter of relative cost, and at the present time the prices of certain proprietary compounds tended to approach prohibitive figures. It was obvious when making cement watertight that there should be enough sand to fill up the voids in the coarse material. There should be more than sufficient cement paste to fill up all the voids in the sand, and if the sand filled up all the voids in the coarse material and the Portland cement paste filled up all the voids in the sand, where was the water to get through? It could only get through if they left out one of the ingredients.

### THE CONCRETE INSTITUTE.

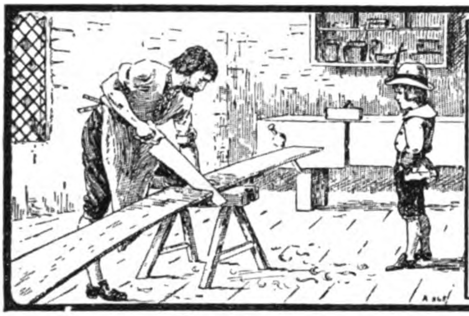
In the latter part of the Address Mr. Etchells dealt with the Institute, and referred to the membership examination scheme. In future the qualification for membership includes B.Sc., B.Eng., Associate Member of the Institution of Civil Engineers, Associate Member of the Institution of Mechanical Engineers (by examination in the two latter cases), Associate of the Royal Institute of British Architects (by examination), the holder of a Commission in the Royal Engineers or the holder of such other degree or qualification as the Council may determine in specific cases. The object of this latter, Mr. Etchells explained, was to allow of the Council admitting to membership practical men who had not gained academic or scholastic distinction. The question has also been considered of the formation of a special class for such people as clerks of works and foremen, it being felt that many of the present risks involved by employing more or less incompetent clerks of works and foremen would be minimized if employers knew that men of this type who were members of the Institute had had to pass some form of examination which gave them a status in regard to the supervision of reinforced concrete constructional work.

Another matter touched upon was the formation of local branches in the Dominions abroad. The Council is at present of the opinion that the time has not yet arrived for this step to be taken, but in any case it feels that the initiative should rest with the local members themselves.

### THE VOTE OF THANKS.

SIR HENRY TANNER, in proposing a vote of thanks, said that the President's remarks on the present condition of the building trade were very apposite. He himself believed that it was not so much want of bricks as want of bricklayers that we were suffering from at the present time, but how these bricklayers were to be obtained under present conditions, when the trade would not allow any other persons to be brought into it, nor would they allow overtime to be worked, he did not know. That was the position in London, which was suffering because men left London to go into the provinces in order to work overtime, where there was not the same restriction upon it. He also agreed with the President as to the disadvantages of using concrete blocks before they were matured. Only within the last three or four days, he had had brought to him blocks which were said to be fit for use, but which could be broken to pieces with the fingers, although in two or three weeks' time they would be thoroughly watertight. He believed in making the concrete itself watertight rather than using artificial means for this purpose afterwards, but at the same time it did seem to satisfy people when they were told that something was put into the concrete to make it waterproof, although it did nothing of the kind.

MR. H. D. SEARLES-WOOD seconded the vote of thanks, which was supported by MR. W. J. H. LEVERTON and carried with acclamation.



# CONCRETE COTTAGE BUILDING.

## COTTAGES AT BROCKLEY.

One of the chief causes of obstruction against monolithic work, for small buildings, in England is the unfamiliarity on the part of all concerned in the use of shuttering. In America there are many forms of patent shuttering that can be cheaply and quickly erected, and that are economical on account of the frequency with which they can be used. During the last few months many similar patents have been put upon the market in England, but as yet they have not met with much success, and this is caused not so much by any inherent defect as by an attitude of suspicion and mistrust. The recent success, however, which has attended a large housing scheme that is being carried out on these lines by the Deptford Borough Council under its Surveyor, Mr. H. Morley Lawson, should do much to disperse existing prejudices.

The scheme is to include 238 houses, and the first contract includes fifty-nine houses, of which nineteen are class " A " (non-parlour) and the remainder class " B " (parlour). It was the original intention of the Council to build the houses of brick, and the choice of concrete seems to have been made by reason of the high costs that were obtaining in other districts for brick houses.

The site is an open one and it is fairly level, the sub-soil is clay at a depth of about 18 in., on this account it was decided to build on a Considère raft. Excavation was carried down to the required depth and a concrete base, 1 ft. 8 in. wide by 1 ft. deep, was put in, consisting of ballast concrete mixed six to one. Upon this 8-in. plinth walls were erected, also mixed six to one between timber shuttering. These walls were carried up to the underside of the raft. The space under the raft was filled in with burned ashes (see *Fig.* 1).

Most of the labour employed upon the scheme is unskilled, and on this account concrete guide pieces were constructed at the corners of the raft, and the walls were marked out. The raft itself consists of a 7-in. thickness of ballast concrete reinforced with a double reinforcement of B.R.C. fabric, 1 in. from the top and 1 in. from the underside. The raft is brought out flush with the outside face of the plinth wall. The top forms the floor level and is covered with an approved jointless flooring.

The party walls are carried up solid in the same way as the plinth walls. The internal walls, however, are built up off the raft without independent foundation. Above the plinth the outside walling is constructed hollow, and is monolithic. It is built by means of the Forrester-Marsh patent system of wall-ties and metal shuttering. The shuttering consists of a plain mild steel plate welded to a piece of ordinary corrugated iron. The latter is used in order to give both strength and lightness. Every sheet has two bolt holes punched to template, and the sheets are joined together somewhat in the manner of continuous sheet piling. Each unit of shuttering measures 5 ft. by 2 ft. or 5 ft. by 2 ft. 6 in.

The external walls consist of a 2½-in. outer leaf of reinforced Thames ballast

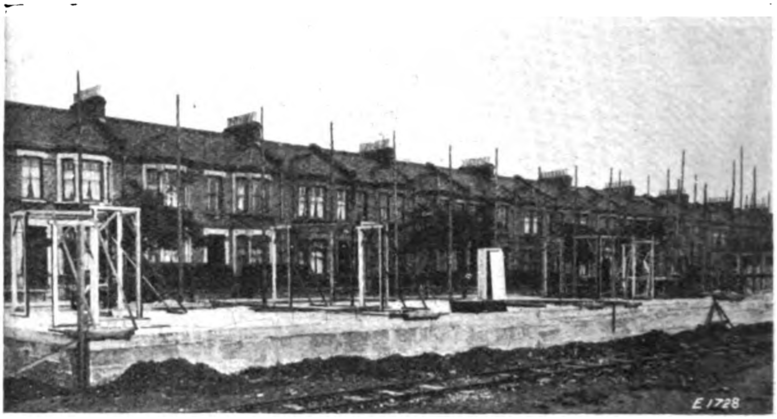


Fig. 1. Showing Concrete Raft.

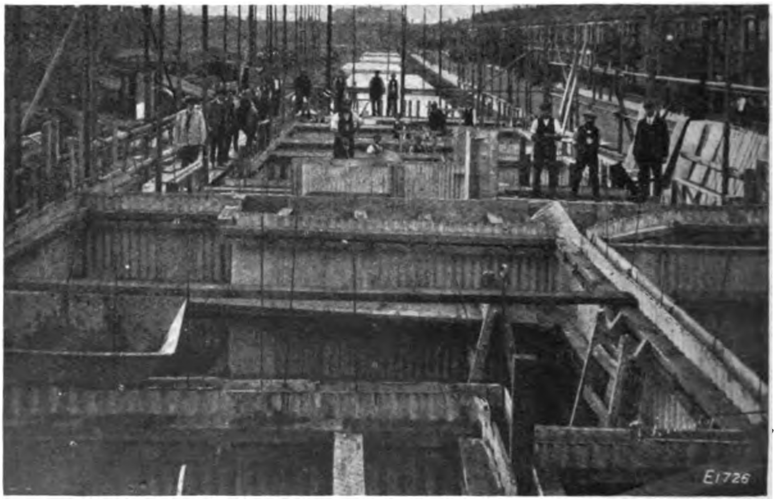


Fig. 2. General View. Deptford Housing Scheme, Brockley.

concrete and an inner leaf of 3-in. reinforced clinker concrete with a 2½-in. cavity. The shuttering is first fixed to a height of 5 ft.; it was originally intended to concrete to a height of 8 ft. in one operation, but the Ministry of Health would not approve this procedure, as it was considered that, since the mixture was a wet one, there might be a separation of the aggregate; the coarser material sinking to the bottom. All door and window frames are fixed in position before the filling is begun. The concrete, which is mixed to a thin consistency, is then poured in by means of a hopper, the narrow neck of which fits into the space between the shuttering (see *Fig.* 2). As the material is being poured, an operator tamps by means of an iron tamper, at 2-ft. stages in height. The shuttering is allowed to remain for at least four days before it is struck. All the walls are carried up uniformly, including party walls, partition walls, fireplaces, etc.

The whole of the walls are reinforced with ¼-in. steel bars, which are inserted, both vertically and horizontally, as the work proceeds. The spacing of these bars is, for party walls, internal walls, and the inner leaf of the outer wall, every 24 in. for vertical rods, and every 15 in. for horizontal, and for the outer leaf of the outer wall every 12 in. for vertical and every 15 in. for horizontal rods.

As the chief novelty of this method of construction lies in the shuttering, it may be of interest if this be described somewhat in detail. The shuttering is erected with the plain side innermost, and it is held in position by means of temporary bolts passing through horizontal battens; this is clearly seen in *Figs.* 3 and 4. In the case of a cavity wall two parallel sets of shuttering are employed which are held apart by means of timber spacing pieces. It will be observed, upon reference to *Fig.* 4, that a temporary frame is erected to form the openings in the inner leaf for doors and windows, the frame proper being built into the outer leaf. The two sheets of shuttering are held apart by means of "spacers," and it is these ingenious contrivances that form an integral part of the patent. The spacer consists of a cylindrical block made of compressed cement mortar bored with a longitudinal hole. A slot is formed across the spacer into which fits a strap of iron, twisted where it passes through the slot. The extremities of these straps are pierced, and through the holes the vertical reinforcement rods are passed; by this means they are held properly in position. These spacers are plainly seen in *Fig.* 3. At one end of each spacer a large hole is countersunk;

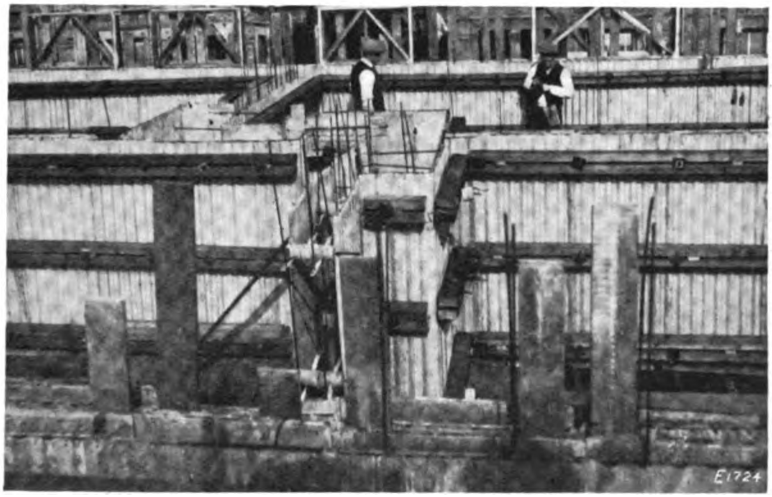
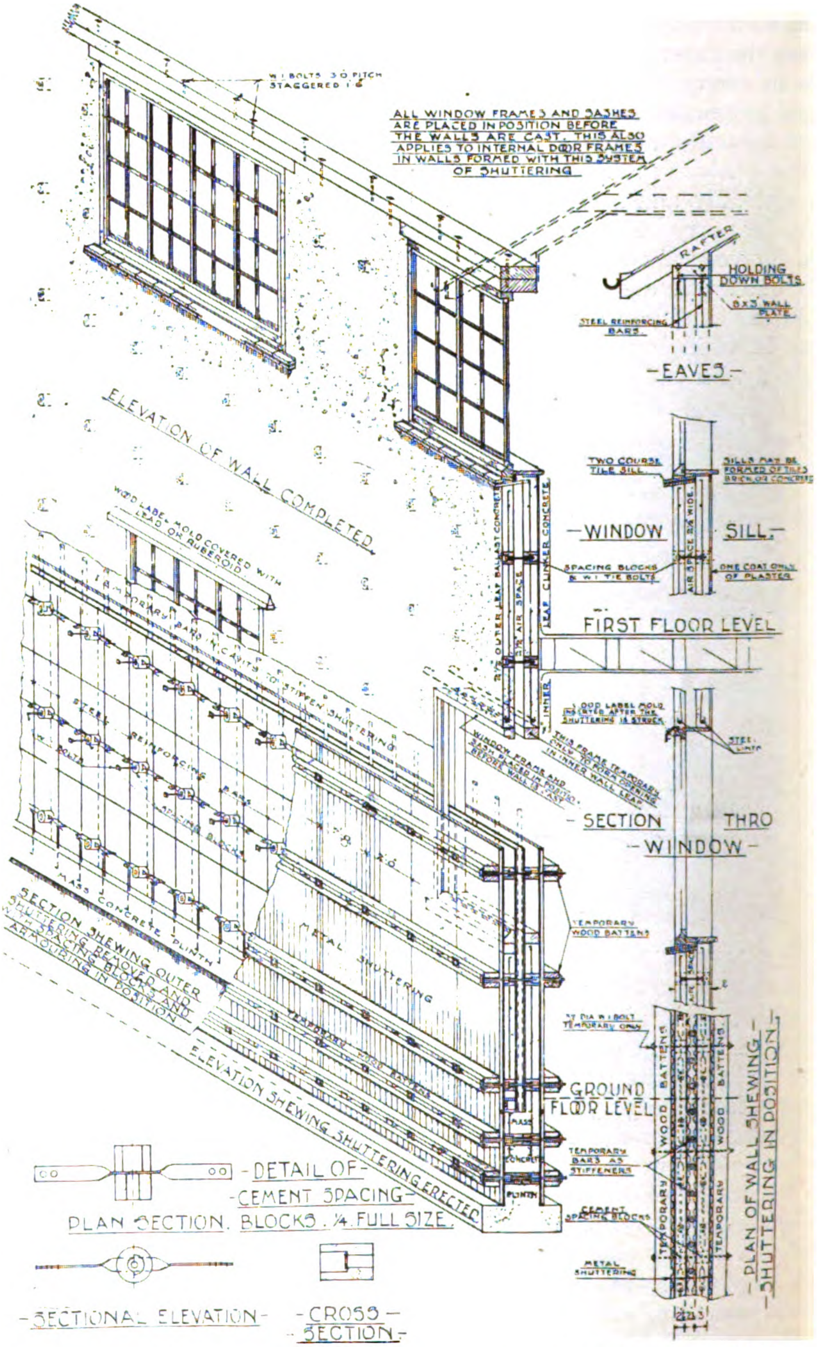


FIG. 3. SHOWING SPACERS TO SHUTTERING AND REINFORCEMENT: THE DEPTFORD HOUSING SCHEME, BROCKLEY.


W. I. BOLTS 3.0 PITCH STAGGERED 1.6
ALL WINDOW FRAMES AND SASHES ARE PLACED IN POSITION BEFORE THE WALLS ARE CAST. THIS ALSO APPLIES TO INTERNAL DOOR FRAMES IN WALLS FORMED WITH THIS SYSTEM OF SHUTTERING
RAFTER
HOLDING DOWN BOLTS
6 x 3 WALL PLATE
STEEL REINFORCING BARS
-EAVES-
ELEVATION OF WALL COMPLETED
TWO COURSE TILE SILL
SILLS MAY BE FORMED OF TILES BRICK OR CONCRETE
-WINDOW SILL-
AIR SPACE 2½ WIDE
SPACING BLOCKS & W. I. TIE BOLTS
ONE COAT ONLY OF PLASTER
OUTER LEAF BALLAST CONCRETE
AIR SPACE
LEAF CLINKER CONCRETE
INNER
FIRST FLOOR LEVEL
WOOD LABEL MOLD COVERED WITH LEAD OR RUBEROID
TEMPORARY BARS IN CAVITY TO STIFFEN SHUTTERING
WOOD LABEL MOLD INSERTED AFTER THE SHUTTERING IS STRUCK
STEEL LINTEL
THIS FRAME TEMPORARY ONLY TO FORM OPENING IN INNER WALL LEAF
WINDOW FRAME AND SASH PLACED IN POSITION BEFORE WALL IS CAST
STEEL REINFORCING BARS
SPACING BLOCKS
BOLTS
-SECTION THRO -WINDOW-
8 x 2.6
TEMPORARY WOOD BATTENS
METAL SHUTTERING
MASS CONCRETE PLINTH
SECTION SHEWING OUTER SHUTTERING REMOVED AND WITH SPACING BLOCKS AND ARMOURING IN POSITION
TEMPORARY WOOD BATTENS
ELEVATION SHEWING SHUTTERING ERECTED
½ DIA W. I. BOLT TEMPORARY ONLY
GROUND FLOOR LEVEL
MASS CONCRETE PLINTH
TEMPORARY BARS AS STIFFENERS
CEMENT SPACING BLOCKS
METAL SHUTTERING
TEMPORARY WOOD BATTENS
-PLAN OF WALL SHEWING- -SHUTTERING IN POSITION-
-DETAIL OF- -CEMENT SPACING- BLOCKS. ¼ FULL SIZE.
PLAN SECTION.
-SECTIONAL ELEVATION-
-CROSS- -SECTION-

*Architect: Ernest Thompson.*

FIG. 4. DETAILS OF FORRESTER-MARSH SHUTTERING. DEPTFORD HOUSING SCHEME, BROCKLEY.

this is formed in order to take the nut which secures a bolt that passes through the finished wall and the spacer. The countersunk hole is filled in, as the work is completed, with cement mortar. *Figs.* 5 and 6 show the work in progress. It will be noticed that all the walls are being carried up at a uniform height. The fireplaces are in concrete, the flues being formed of drain pipe.

The finished house, of which *Fig.* 10 is an illustration, is rough-casted and colour-washed on the outside and rendered internally with cement mortar, the corners of all the rooms being rounded. Only a thin skimming coat of plaster is necessary and an estimated saving of 75 per cent. in plastering is effected.

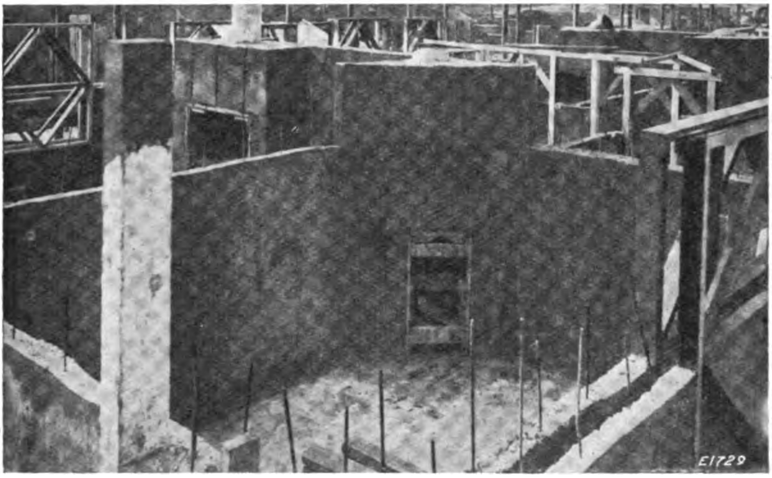


FIG. 5. SHOWING OUTER CAVITY WALL, PARTITION AND FIREPLACE.

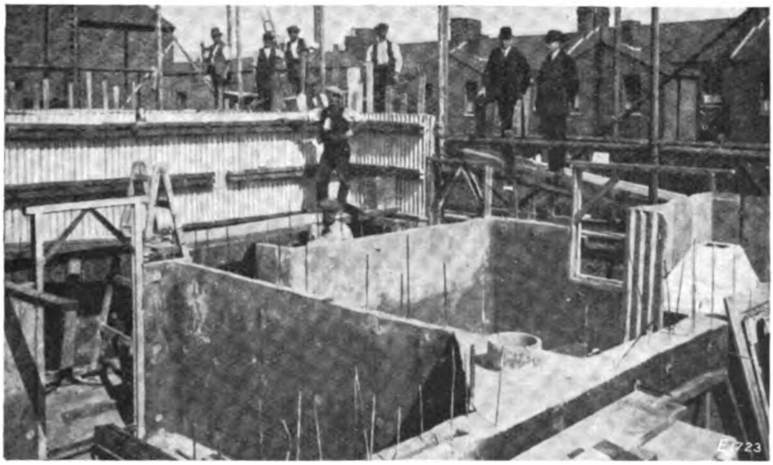


FIG. 6. SHOWING SHUTTERING IN SECOND POSITION. THE DEPTFORD HOUSING SCHEME, BROCKLEY.

An interesting point about this scheme is the large amount of unskilled labour that is employed, all the men, indeed, except the foremen, being unskilled. It is stated that four days is sufficient time in which to train a man so that he

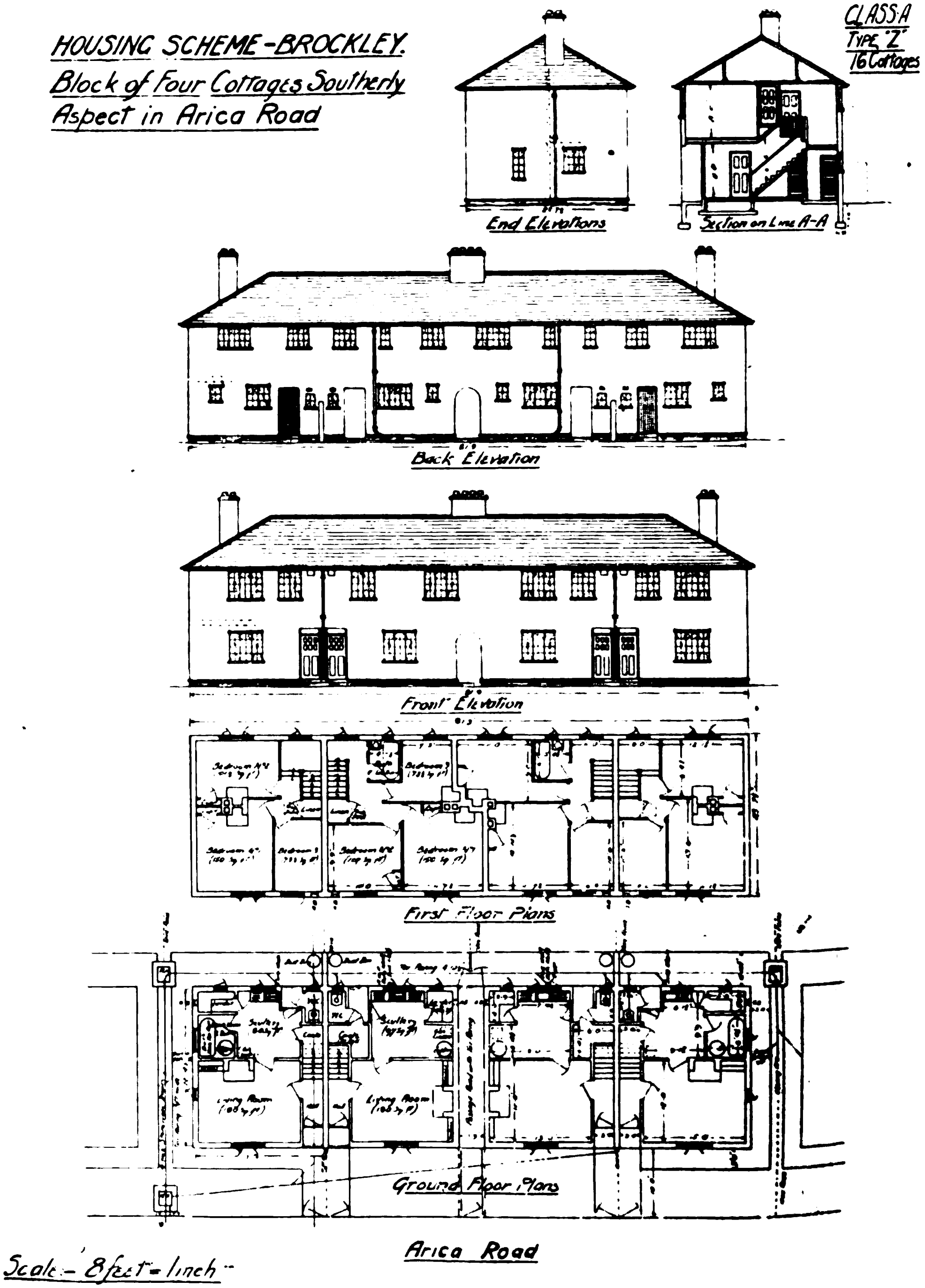


FIG. 7. DEPTFORD HOUSING SCHEME, BROCKLEY: HOUSE PLANS.

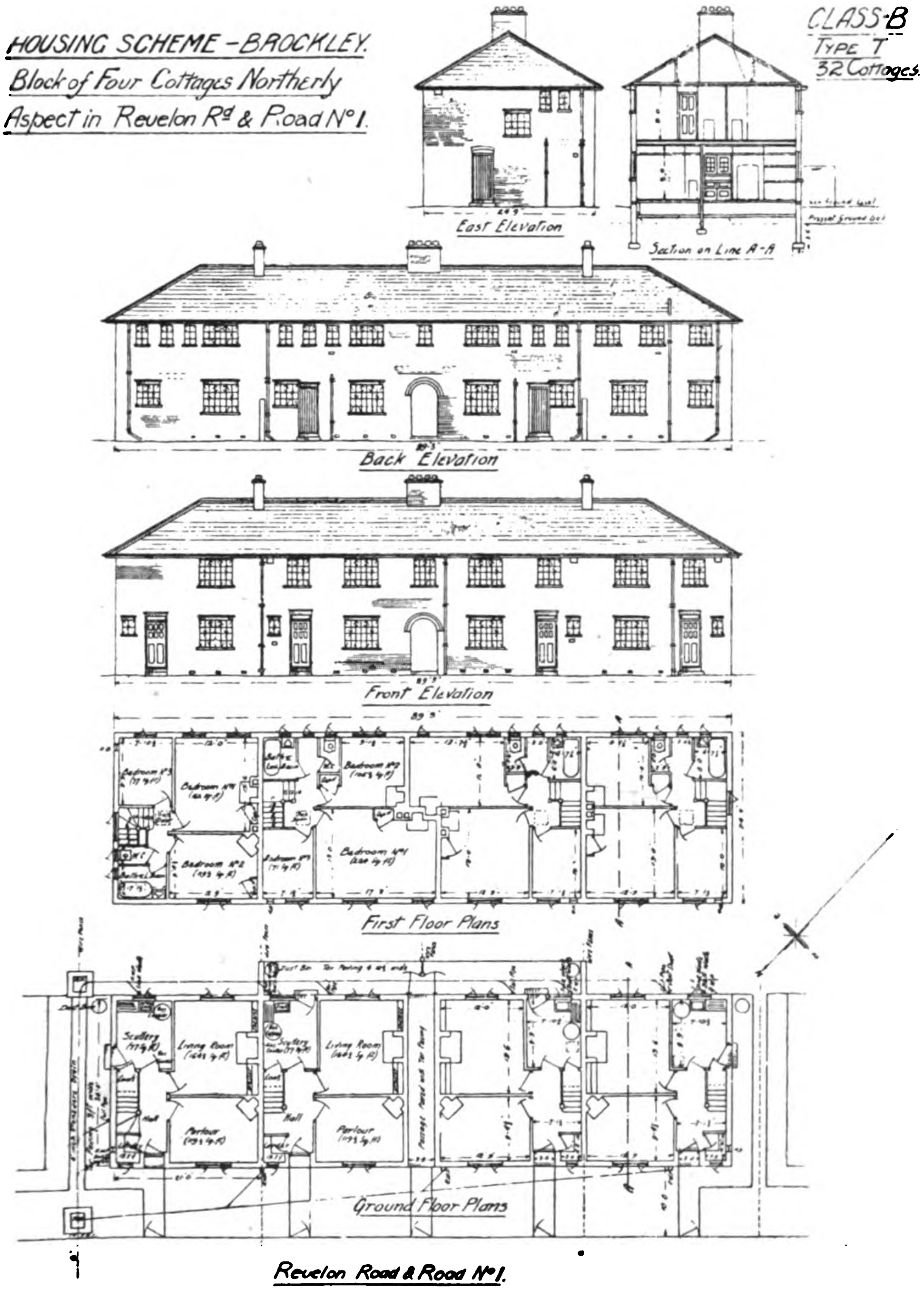


FIG. 8. DEPTFORD HOUSING SCHEME, BROCKLEY: HOUSE PLANS.

may be of use, while in fourteen days he can be made really efficient. Particular care has been taken in the organization of this job. Two mixers are employed: a "Ransome" and a "Millar" portable mixer. After being mixed the concrete is run on rails to the point required, and, in the case of the upper storey, it is elevated by a hand pulley. There are seventy-five men on the job.

The work is at present hardly sufficiently advanced to give actual figures as to cost, but, from analyses which have been kept for the first blocks of houses, it would appear that the walling itself works out at approximately the same price as brickwork per yard super., allowing £50 per rod for brickwork. It should, however, be observed that this figure is based, as before stated, on the earlier work, which was of necessity somewhat of an experimental nature, and it is fully anticipated that as the work proceeds the men will become more efficient in erecting the shuttering. This will expedite and consequently reduce the cost of the work.

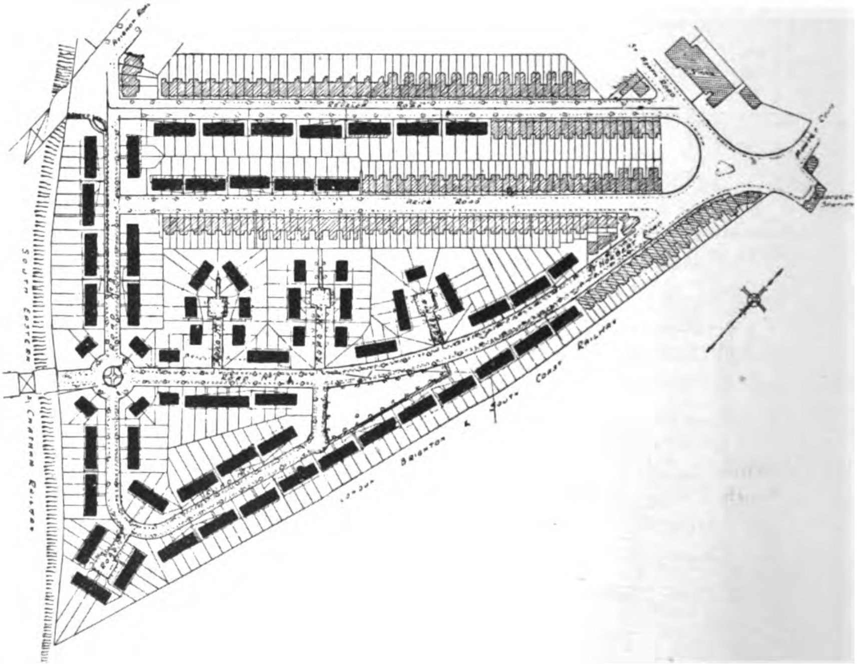

South Eastern & Chatham Railway
London Brighton & South Coast Railway

Fig. 9. Deptford Housing Scheme, Brockley: Layout Plan.

Some of the shuttering at present on the job has been used some fifty or sixty times, and it is believed that the life of the sheets will be some five or six years. A block of four houses can be built in twenty-four days, with a week longer to complete the roof.

As has already been mentioned, the shuttering remains in position at least four days after the date of the final pouring; it is then struck and re-erected for the upper portion of the wall. The shuttering overlaps the finished wall below by about 6 in. The lower holes of the sheets in the upper position register with the upper holes in the lower position. The eaves are finished with a solid wood wall plate to the full width of the wall. This plate is bolted down with rag bolts into both leaves of the wall. The reveals to the windows are covered with expanded metal and rendered. Corner stirrups are built in at all angles and division walls as an additional reinforcement to the bars which have been already mentioned.

*Figs.* 7 and 8 show plans of two types of houses at present in course of erection, while *Fig.* 10 shows the general layout of the whole scheme. The improved method of development is very apparent. The wide-fronted houses, pleasantly arranged on axial lines with *cul-de-sacs* and courts, compare very favourably with the long overcrowded lines of terrace houses, each with its back projection obscuring sun and air from itself and its neighbour. If the design of the new houses appears somewhat dull, it must be remembered that the whole estate gains not a little by the new method of grouping, and there is little doubt that when the whole scheme is completed it will form an addition to the district for which no one, who has been associated with it, will have cause to be anything but proud.

It is said to be more than likely that H.H. The Jam of Nawanagar (" Ranji ") will reconstruct his Capital (recently demolished by the floods) on the Forrester Marsh system. A report has been prepared by Mr. F. C. Nissen, the manager and engineer-in-chief of His Highness, which is of a very favourable character, and it is understood that negotiations are now in progress between the parties. In his report, Mr. Nissen says, " that the system is a distinct advance on existing practice, both in point of simplicity and cheapness, is beyond question, and it would not be too optimistic to say that it will in a short time supplant existing methods of reinforced concrete construction. . . . There appears to be no limit . . . to the extent to which the system could be carried, as it is purely a matter of ingenuity in the design and construction of the moulds with which numerous pleasing architectural and colour effects could readily be obtained. In the tropics there would certainly be a great field for this system . . . monolithic sheds, warehouses, and tenements would also be invaluable at railway stations, docks and other centres by reason of the protection they would afford against rats and the plague."

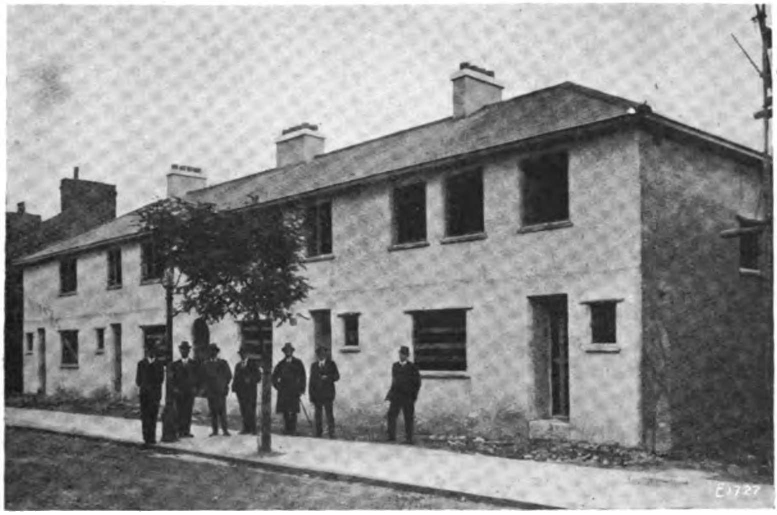
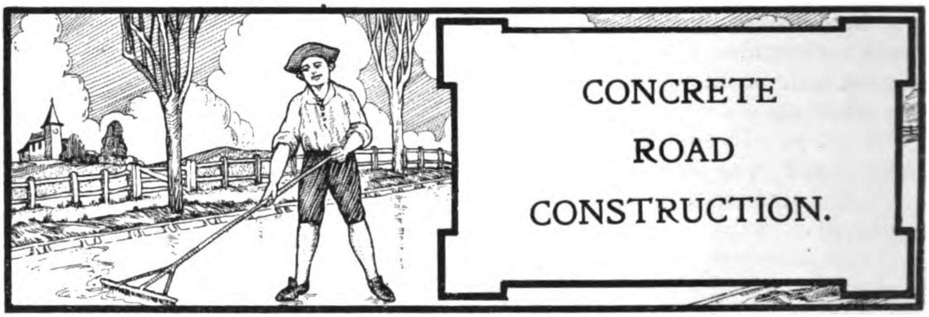


FIG. 10. BLOCK OF NEARLY FINISHED HOUSE. THE DEPTFORD HOUSING SCHEME, BROCKLEY.



# CONCRETE ROAD CONSTRUCTION.

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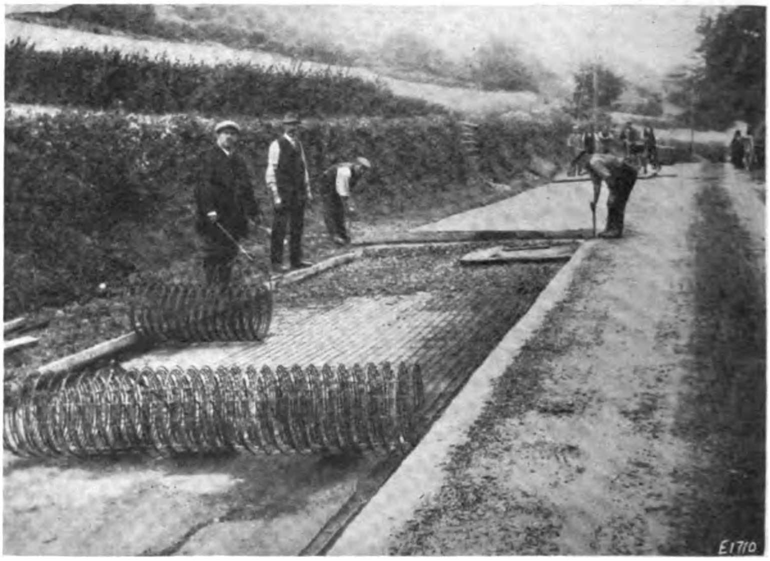
## ABERGAVENNY AND BRECON MAIN ROAD, WALES.

WORK was commenced on this road at a point near the Brecon boundary in September, 1919, under the supervision of Mr. S. A. Bennett, A.M.Inst.C.E., the County Surveyor, one half width being laid at a time. After about 100 yds. had been laid this portion was fenced off for twenty-eight days, after which the traffic was turned on to it while the other half of the road was being constructed.

No longitudinal joint was made in the concrete, but a double layer of the reinforcing fabric about 18 in. wide was laid at the centre of the road where the two halves met. Expansion joints were provided, but instead of being placed at right angles to the direction of the road, these were laid diagonally at intervals, and were filled with bituminous material.



ABERGAVENNY AND BRECON MAIN ROAD, SHOWING A PART OF THE ROAD FINISHED AND PART IN COURSE OF CONSTRUCTION.

The concrete, which is 6 in. in thickness, was laid in one course and consisted of crushed furnace slag, graded from 2 in. to ½ in., sharp fresh water sand, and Portland cement in the proportion of 4½ slag, 1½ sand and 1 cement.

Before being opened to traffic the surface was tarred and spread with a ½-in. coating of granite chippings.

On account of the water-logged sub-soil, diagonal cross drains were laid in the road, with 4-in. pipes, open jointed, the trenches being filled in with 6-in. broken slag. These cross drains are connected to a 6-in. longitudinal drain under the footpath, the drainage water being discharged into watercourses.

The width of the roadway is 20 ft., and the length so far completed is about 800 yards.

The nature of the traffic over the road is both heavy and continuous, and consists of heavy steam tractors with trailers, commercial motor lorries and a frequent omnibus service in addition to the ordinary local traffic. Prior to the concrete being laid, the road was constructed with most of the known proprietary materials, but on account of the soft nature of the sub-soil it became almost impassable on account of corrugations and depressions.

The County Surveyor, reporting on the condition of the road in November, 1920, says, " So far the concrete road has been a complete success, having withstood the traffic, and showing no signs of disintegration or of any cracks."

LONGHOUGHTON ROAD, NORTHUMBERLAND.

### LONGHOUGHTON ROAD, NORTHUMBERLAND.

In May, 1920, the first reinforced concrete road in Northumberland was commenced by the Alnwick Rural District Council under the supervision of their Highway Surveyor, Mr. Nicholas Bean. The road, which begins at the Longhoughton Railway Station, is about a quarter of a mile in length and 24 ft. in width. With a gradient of 1 in 18 this hill has always been a source of trouble to the authorities, since, being the main outlet of the Northumberland whinstone quarries, it has to bear very heavy traffic, consisting mainly of steam wagons carrying loads of five tons of stone between the quarries and the railway, and has always had a tendency to " creep."

The concrete, which is 9 in. thick, was laid on a bottom of whinstone setts and consists of 2½ parts of Northumberland whinstone chippings graded from 1½ in. to ½ in., and 1½ parts of ⅜-in. chippings and coarse whinstone grit, to 1 part of Portland cement. This aggregate is an ideal one for road work, being of a very hard, dense nature.

### THE MAIN NORTH ROAD.

The first section of this road to be laid in reinforced concrete is situated between Wideopen, about five miles north of Newcastle, and Seaton Burn, a length of about one mile. The road is practically level, the only gradient being 1 in 30.

The concrete, which was laid on the top of the existing road, was mixed in the proportion of 3½ parts of crushed whinstone 1½ in. to ½ in., and 1½ parts ⅜ in., mixed with coarse whinstone grit to 1 part Portland cement.

The thickness of the concrete is 6 in., the reinforcement being placed about 2 in. from the under side.

The cross-fall is about 1 in. to the channel, and the surface is finished with tar paint and chippings.

As it was impossible entirely to close this main road, the concreting was done in half-widths, each section being opened to traffic five weeks after completion. At the time of going to press one half of the road has been finished and is said to be standing exceedingly well. It is the intention of the County Council, who have acquired some of the most up-to-date road-making plant, to lay about six miles of concrete road, and for this preparations are being made. The work is being carried out under the direction of the County Surveyor, Mr. J. A. Bean, C.E., F.G.S.

The reinforcement used in all these three roads was B.R.C. Fabric.

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## SOME RECENT VIEWS REGARDING CONCRETE ROADS IN THE UNITED STATES.

Below we give a number of extracts taken from letters written by the various city surveyors of different towns in America, in which they report on concrete roads in their respective counties.

**City of Superior, Wisconsin.**—The City Engineer, Mr. E. J. Banks, writes on March 29, 1920: " . . . The good showing which concrete made in a number of alleys paved in 1909 led to the conviction in 1912 that it was worth trying on streets of medium and light traffic, and during that year about 20,000 square yards were laid. Since that time more than 400,000 square yards have been put down, and the use of concrete has been extended to streets carrying heavier traffic.

" We have never regretted our action in this matter, and it is my opinion, based on our experience in laying and maintaining 421,000 square yards with a total length of 24·68 miles, that a properly constructed concrete pavement is the best investment to which the property owners' money can be put."—(*Signed*) E. J. BANKS, City Engineer.

**Yankton, South Dakota.**—The first concrete pavement was constructed in 1915 and consisted of 23,000 square yards. According to a report of the City Surveyor in March of this year: " This pavement is in excellent condition at this time. In 1916–17 the city constructed 78,000 square yards more and will call for bids on 71,000 square yards again this year.

" The maintenance cost on the 1915–16–17 pavement has been less than $1.00 per mile per year.

" After the 1920 pavement has been constructed the city will have 110 blocks of concrete pavement, or 8·5 miles."—(*Signed*) H. H. CORBIN, March 15, 1920.

**Norfolk County.**—Mr. R. B. Preston, County Engineer, writes: " We have approximately 23 miles of concrete roads, which have proved eminently satisfactory, the maintenance cost on same being very low, in spite of the fact that the roads have been subjected to extraordinarily heavy traffic. . . . I can readily recommend concrete as a type of surface for roads."

A good many miles of additional roads of this character are recommended to be laid within the next two or three years.

# CONCRETING IN COLD WEATHER.

It has often been stated, and, indeed, it is generally understood that concrete work should be suspended during the winter, or, at any rate, when frosty conditions prevail. This, however, need not be the case. If proper precautions be taken, concrete work may be carried on successfully in all weathers and in any temperature. The object to be aimed at is, of course, to keep the wet mixture considerably above freezing point until setting has taken place, after which temperature and other climatic conditions have no effect.

By adopting very simple and obvious methods in preparing the material and using means to protect the concrete when freshly placed, the resulting work will be as successful as though carried on in warm weather. By adopting these measures some slight additional cost may be incurred, but this will be more than counterbalanced by the gain resulting from the work being able to be carried on without cessation all the year round.

The principles involved are as follows: Heat hastens the hardening of concrete; cold delays it. If wet concrete is frozen, but after thawing out is not again frozen, the only result is a delay in the setting. If, however, the material is allowed to freeze and thaw at intervals the concrete is damaged beyond repair. It is safer, therefore, to protect the concrete from freezing at the outset. If such protection is given until the concrete is thoroughly set, no injury need be feared no matter how low the temperature.

In considering the requirements for successfully carrying out concrete work in cold weather, regard must be had to the conditions under which the setting and hardening of the concrete take place. The prime factors in these processes are warmth and moisture, and any means that will produce these conditions in cold weather will lead to the same success as that which is met with when concreting during the summer months. The only way by which this end may be achieved is the heating of the materials, and the protection of the freshly laid concrete from frost. We will first consider the former, viz. the heating of the materials.

The heating of the mixing water is not a difficult problem. On small jobs the water may be heated in tanks or kettles over a fire, or if a steam engine is used to run the mixer the exhaust steam may be allowed to discharge into the water tank. On large jobs, however, where considerable quantities of water are required, better results will be obtained by heating the water with live steam, that is, steam under pressure, since this furnishes more heat. For this purpose, an old steam boiler that is no longer safe for carrying high steam pressures may conveniently be used as a source of steam supply. The water should be heated to 150° F.

The next point is the heating of the aggregate (the cement, forming such a small proportion of the whole does not need to be heated). This may be done in various ways. On small jobs the materials may be heated by piling them over and around iron pipes or an old boiler or anything which may be used as a stove in which a fire may be kindled. During the heating, the material should be constantly turned over, otherwise that nearest the " stove " may become too hot and so damaged, and that on the outside may be hardly warm.

On large jobs it is more advantageous to heat the aggregate by steam. The materials may be piled on steam-heated pipes or, covered with tarpaulins, they may be heated by directly applied steam. In the latter case, the pipe, closed at one end, is perforated with a large number of small holes, and when the steam is turned on the aggregate in the vicinity of the pipe is heated to the requisite degree, which should be, as in the case of the water, about 150° F., so that when deposited the concrete shall have a temperature of 75° to 80°.

Another method, and one that has been employed in America, is the application of heat during mixing. This is done by means of the flame from a kerosene torch. The torch, having a 20-gallon fuel tank, is installed on the mixer. The tank is put under a pressure of about 85 lb. and the flames from the torch directed into the discharge end of the mixer, almost completely filling the drum, and coming in contact with the mix as the drum revolves.

At one time the practice of adding common salt to the mixing water was advocated as a means of overcoming the difficulty of successfully concreting in cold weather, but this is a fallacy. Of course, water containing common salt freezes at a lower temperature than pure water does, but since it delays, instead of hastening the hardening of the concrete its use is to be deprecated. Another objection to the use of salt in reinforced concrete work is the danger of the corrosion of the steel.

Metal forms should always be heated when used in frosty weather, and when the cold is severe it is advisable also to heat wooden forms. This may best be done, where such means are available, by turning a jet of steam against the form faces.

After the concrete has been placed in position, steps must be taken to protect the work from frost. Floors, roads, footpaths and similar classes of work may be protected by a covering of straw laid on paper or canvas. The layer of straw may be from 6 to 12 inches in thickness according to the temperature. Where the work is out of doors, the covering must be weighted down, in order that the protecting material may not be blown away. It is a good plan to cover the whole with sacks upon which boards, stones or other heavy substances may be laid.

Where it is possible, a satisfactory method of protection against frost is the erection, over the work, of a canvas covered frame, and the enclosure kept warm by stoves, braziers or salamanders.

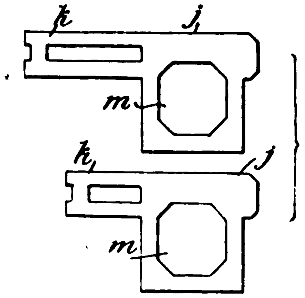
Since concrete hardens more slowly in cold weather it is of the greatest importance, especially in the case of such structures as roofs and overhead floors, that forms should not be removed until it is absolutely certain that the material is strong enough to be safe. Frozen concrete may easily be mistaken for concrete which has thoroughly set, since it is hard and, if struck with a hammer, will ring just as hardened concrete does. If there is any doubt about the matter, a portion of the concrete should be exposed and a jet of steam or hot water, or the flame from a blow-lamp directed upon it. The concrete if hardened will not be affected by this operation, but if merely frozen the water will thaw out leaving the material soft.

In road work it is important to remember that concrete should not be placed on a frozen sub-grade, and that if the aggregate contains lumps of frozen material the latter must be thawed out before use.

# RECENT BRITISH PATENTS RELATING TO CONCRETE.

*We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete, the articles being prepared by Messrs. Andrews and Beaumont, Patent Agents, of 204-6, Bank Chambers, 29, Southampton Buildings, W.C.2. The last article appeared in our issue of August, 1920.—ED.*

**Concrete Slab Buildings.**—*No.* 142,965. *F. B. Smith, The Poplars, Aberavon, Glamorganshire. Dated March* 10/19.—In carrying out my present invention, which is an improvement upon Patent No. 124,902, concrete or metal upright members of T or H-shape are employed, and instead of fitting the uprights in the base-blocks and head-pieces, the ends of the uprights rest on the head-pieces and base-blocks, the head-pieces and base-blocks being provided with raised and cut-away portions and the uprights with ends partly cut away so that said uprights can take over and seat, on the raised portions of the base-blocks and head-pieces. The T-shaped stanchion (*a*) is cut away at its end (*b*) in the manner shown in *Figs.* 1 and 3; the head-piece and base-block (*c, c*) are each provided with a raised portion (*e*) on which the T-shaped stanchion by its cut-away portions rests; the cut-away portions (*f*) of the base-block receive the ends of the sole-pieces (*g*), and slabs (*h*) are provided which fit the T-shaped stanchion in the manner shown in *Fig.* 2. Three of the slabs (*h*) are provided with grooves which take over the ends of the flanges and webs of the stanchion, whilst the fourth slab (*h*) may be left plain to butt against the flange of said stanchion, and the beams (*i*) rest on the head-piece (*c*) as in *Fig.* 1. *Figs.* 12 and 13 show a compound flue block and slab; these are constituted by a block (*j*) provided with an extension (*k*) at right angles to the block, the extensions (*k*), which are hollow, forming the slab portion, and in the block portion (*j*) is formed a suitably shaped hole (*m*) which, when the compound blocks are laid, constitutes the flue, the blocks breaking joint in the manner shown.



Figs 12.

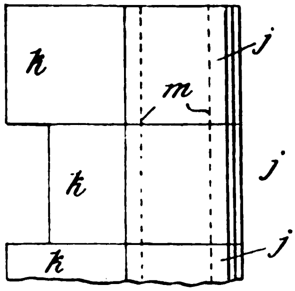


Fig. 13.

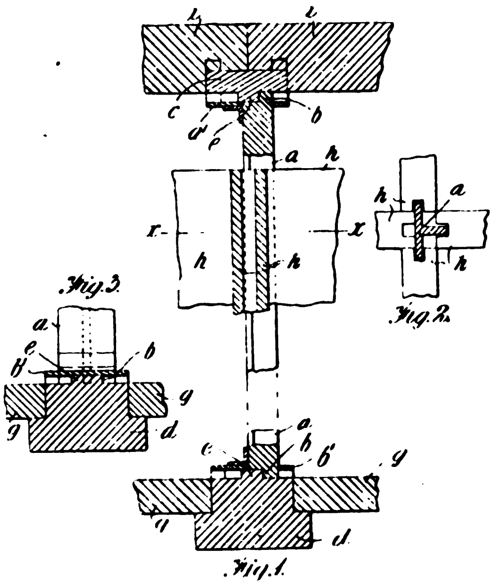
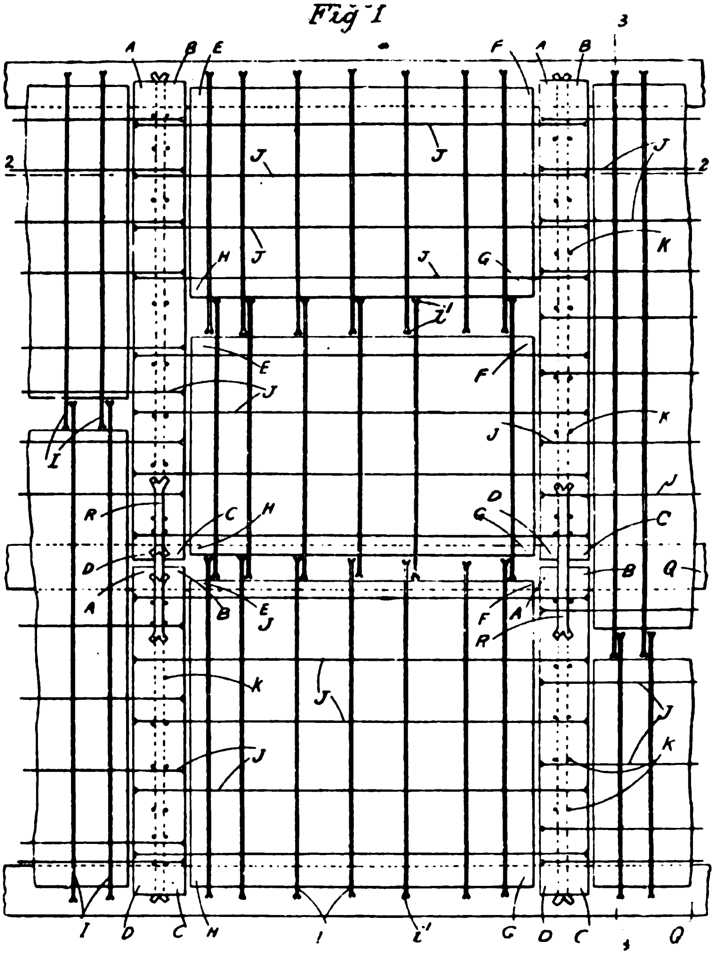


Fig. 3. Fig. 2. Fig. 1.

**Reinforced Concrete Floors.**—*No.* 143,598. *J. H. De Warrenne Walker*, 115, *Grafton Street, Dublin. Dated September* 17/19.—This invention relates to the construction of reinforced concrete floors of the kind formed of pre-cast beams and floor sections having projecting reinforcements which are overlapped, the whole being connected together *in situ*.

According to this invention temporary shuttering is secured to the beams so as to provide a surface, clear of the beams, on which the ends of the floor slabs are supported.

*Fig 1*



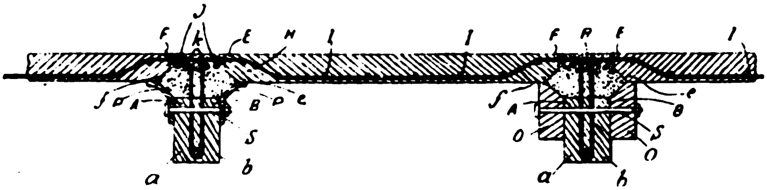
Where the beams are carried over partitions or other supports they may be made in two or more sections, which are united or made continuous by means of a tension bar or bars laid substantially in the plane of the floor.

The pre-cast beams (*A*, *B*, *C*, *D*) and floor sections (*E*, *F*, *G*, *H*) are provided with projecting reinforcements (*I*, *J*, *K*) which are overlapped and may be treated in any of the various ways of providing anchorage in the concrete such as by hooking or fish-tailing.

The pre-cast beams and floor sections are finally united by casting concrete *in situ* between the two contiguous ends (*H*, *G*, and *F*, *E*) of adjacent floor sections, which concrete unites the whole of the units to form the floor; pieces of wood (*O*) or iron (*P*) or other suitable material being used to hold the pre-cast beams and floor sections in place with the floor sections clear of the beams until the cast *in situ* concrete has hardened, when the shuttering may be removed if so desired.

The pieces of timber (*O*) or iron (*P*) or other material are temporarily held in position by bolts (*S*) or clips or other suitable fastenings.

Fig 2



**Hollow Slab Walls.**—*No.* 143,601. *W. R. Smith,* 3, *Hope Villas, Laleham Road, Staines, Middlesex. Dated February* 20/19.—This invention relates to hollow walls of the kind formed of pre-cast reinforced concrete slabs of any size as panels and reinforced concrete beams, posts, columns, lintels, sills, etc., cast *in situ*.

According to the present invention the ends and edges of the slabs (*A*) are flanged or returned at right or other angles to the face of slabs, and pairs of slabs are placed together so that they form enclosed spaces (*D*).

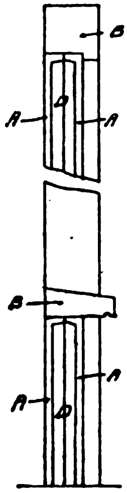


Fig. 1.

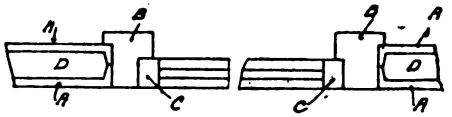


Fig. 2.

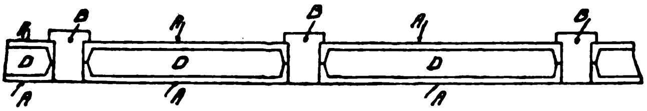


Fig. 3.

The columns, posts, beams, sills, etc. (*B*), are then cast *in situ* between the ends of the slabs.

The walls may be treated with petrifying or other liquid or be plastered externally and internally with pitch, tar, varnish, or other waterproofing material, or with lime or cement plastering as desired.

Additional nibs may be cast on the panels as desired and the slabs may be tied together with wire or other wall ties.

**Reinforced Concrete Beam Structures.**—*No.* 143,632. *A. Drew,* 4, *Westminster Palace Gardens, Westminster, London, S.W.*1. *Dated February* 26/19.—The present invention consists in a reinforced-concrete girder or beam of " I " section provided on both sides of the web with fillets projecting transversely beyond the edges of both flanges to effect at both flanges locking of the beam against movement in either direction normally to the plane of the flanges with respect to similar beams placed alongside.

A reinforced concrete floor beam is formed of a central web (*a*), say approximately 1 in. in thickness, and top and bottom flanges (*b*) extending on each side of this web, each flange being, say 3 in. from the centre of the web to the edge of the flange, the total width therefore being 6 in. The total depth is preferably made also equal to the total width of the webs, namely, in this case 6 in. The end view of this construction is, therefore, an " H " laid on its side.

At intervals along the length of the beam projecting fillets (*c*) are formed. These fill the space between the flanges and extend to a certain extent beyond them. The thickness of the fillets may conveniently be 1 in., and they project alternately on each side of the central web, the distance between the centre line of the flanges and the projecting edge of the fillets being, say 4½ in., and therefore between adjacent flanges on any one side 9 in. These fillets thus project as indicated beyond the flanges and form a double key with the flanges of adjacent beams preventing independent movement of the beams either upwards or downwards.

The construction is reinforced in any suitable way, for instance by steel rods (*d*) extending throughout the length of the web both at the junction of the top and of the bottom flanges with this central web, the concrete being suitably proportioned at these places to accommodate the reinforcements and by stirrups (*e*), say of ¼ in. diameter, arranged in pairs bent right and left in the flanges (only the stirrup with ends bent to the right being shown in *Fig.* 1). For a simple floor a number of the beams are placed in position horizontally with their ends resting upon the supporting walls or girders, rigidity of the floor as a whole being ensured by the interlocking in both upward and downward direction between adjacent beams effected by the fillets.

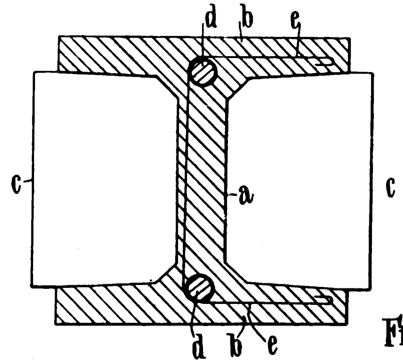


Fig. 1.

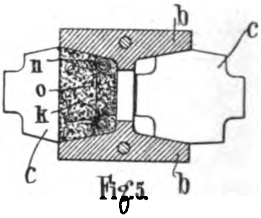


Fig. 5.

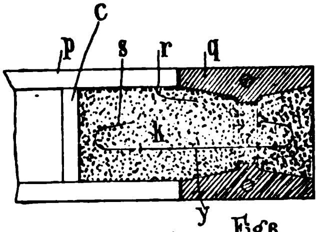


Fig. 6.

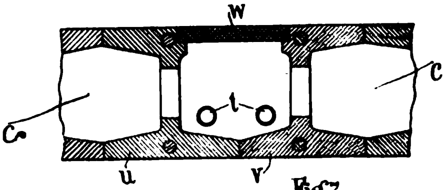


Fig. 7.

To strengthen a beam unit to withstand extra bending or shear stress, longitudinal rods (*n, Fig.* 5) and wire stirrups (*o*) are embedded in concrete filling (*k*), which is accommodated between the flanges (*b*) of a beam on one side of the web after the separate fillets (*c*) have been fitted. Similar strengthening means can be applied to both sides of the web and rigid fillets may be employed.

*Fig.* 6 shows a detail in which a beam (*p*) is required to be connected at right angles with a beam (*q*). Part of both flanges and web of beam (*p*) is broken away to permit of the remaining portion of the web (*r*) to rest rigidly within the housing formed by the web and flanges of beam (*q*), reinforcement (*s*) and concrete filling (*k*) combining to render the joint perfectly rigid.

Pipe ducts as in *Fig.* 7 may readily be provided in floors, within the space between the webs of adjacent beams, fillets between the beams being either dispensed with, broken away or formed with suitable apertures.

*Figs.* 10-12 illustrate the application of the invention to retaining walls.

**Concrete Slabs.**—*No.* 143,691. *Bell's United Asbestos Co., Ltd.,* 59½, *Southwark Street, London ; Evelyn Hurden, "The Gables," Harefield, Nr. Uxbridge, Middlesex ; and John Arthur Cann, "Old Orchard," Harefield, Middlesex. Dated April* 15/19.—

This invention consists in an improved method of production of slabs composed of cement-concrete faced with cement-asbestos. A reinforcement of wire netting or of interlaced wires is, in some instances, introduced between the concrete body of the slab or block and its cement-asbestos facing.

A mould, corresponding with the slab or block to be produced, is lined with a thin sheet of the cement-asbestos compound whilst yet in a freshly made condition, and before it has had time to set the mould is filled with cement-concrete. The facing material and the filling material are then allowed to set simultaneously, with the result that they become firmly united and form an integral body.

Where the addition of a metallic reinforcement is deemed desirable, it is introduced prior to filling the line mould, the metallic reinforcement being preferably of an open-mesh character, so that the concrete filling may readily pass therethrough and unite with the facing material.

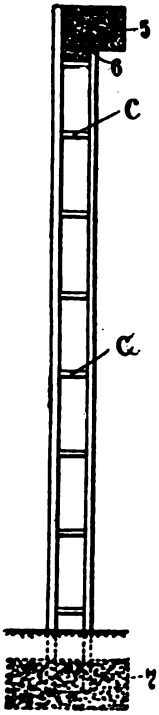


Fig. 10.

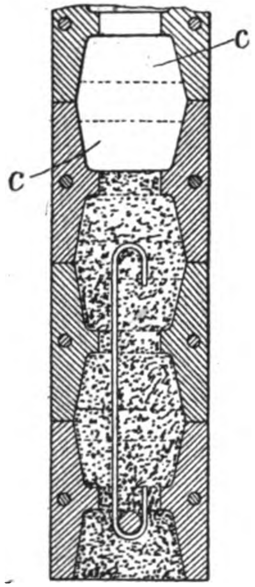
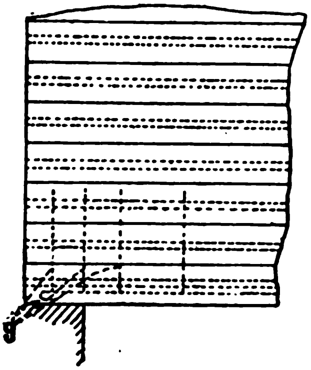


Fig. 12.



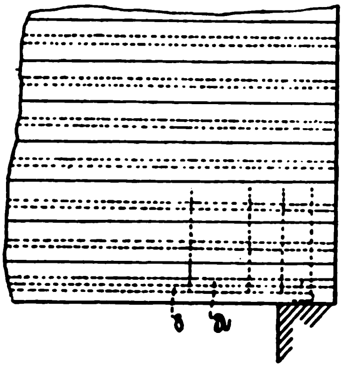


Fig. 11.

As the facing material when applied to the mould is in a wet condition and possesses but little inherent cohesion, it is incapable of being handled as a sheet. In carrying out this stage of the process, a roller is coated with the cement-asbestos composition, and, thus supported, is placed over the mould. The covering is then divided lengthwise of the roller and allowed to fall into the mould. Although in a moist and imperfectly coherent condition, the facing material may, nevertheless, be arranged by hand so as to cover not only the floor, but the side of the mould. Unless the sides of mould are lined in this manner, the edges of the resultant slab or block are left unprotected and are liable to injury. Where both sides of the slab or block are required to be furnished with the cement-asbestos facing material, the latter is simply folded over the concrete-charged mould, and loaded with merely sufficient weight to ensure intimate contact between the covering and the body portion of the slab or block.

**Reinforced Concrete Beams.**—*No.* 144,193. *Walter Wilson, South Dewar Street, Dunfermline. Dated April* 22/19.—According to this invention, which is an improvement upon that described in Patent No. 103,681, the reinforcing wires, cables, etc., are held at tension between frames located at the ends of the mould and provided with removable cross-rods with sleeves thereon, on or about which the wires, etc., are stretched.

Each end frame, as shown, comprises a pair of angle-irons spaced apart to suit the width of the mould and bent up to form uprights (1) and base flanges (2), which may be strengthened by ties (3). The mould is completed by side boards (*D*) and end boards (*D*) erected between the uprights (1). The angle-irons are adjustably secured at the ends of the mould by means of bolts (4) which are fixed in the foundation and pass through elongated openings (5) in the base flanges (2).

The uprights (1) of each end frame are provided with a corresponding number of openings adapted to receive cross-rods (6) on which sleeves (7) are mounted between the uprights. The main reinforcing wires, or cables (*C*), are connected to the sleeves (7) at each end of the mould and are stretched and tensioned by means of screw couplings or otherwise.

For the purpose of subjecting one or more of the reinforcing wires or cables to additional tension, side frames (8) are or may be provided. Each side frame (8) is secured to the foundation (*A*) and has a screw clamp constituted by a sliding block (9) which is attached to a screw (10) threaded in the upper portion of the frame, the screw (10) being provided with an operating handle or hand-wheel (11).

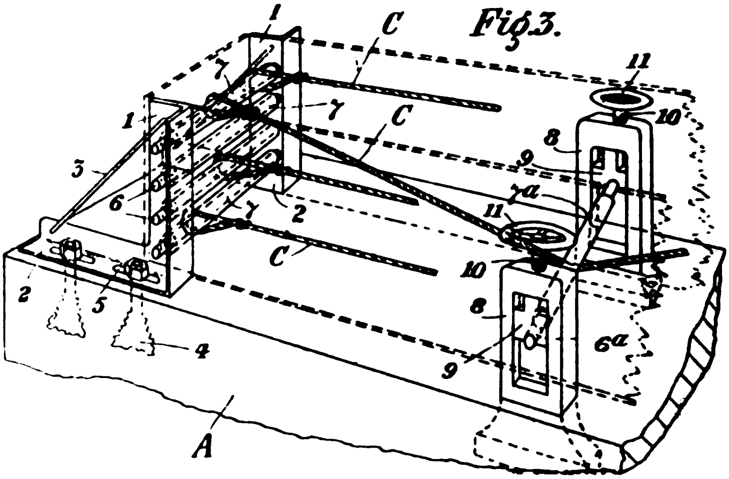


Fig. 3.

When the concrete is thoroughly set the cross-rods (6, 6*a*) are removed. Owing to the tension of the reinforcing wires the sleeves (7) around which the wires are passed are drawn tightly against the supporting rods (6), but this pressure can be relieved by slackening back the nuts on the foundation bolts (4). The pressure on the cross-rod (6*a*) is relieved by simply screwing back the blocks (9) from engagement therewith, after which the rod can be withdrawn.

After the rods (6, 6*a*) have been removed the beam is taken out of the mould with the reinforcing wires or cables and the sleeves (7 and 7*a*) embedded therein. The sleeves (7 and 7*a*) embedded in the concrete serve as means whereby the beams can be jointed together by fish-plates and bolts.

**Concrete Structures employing Pre-cast Members.**—*No.* 144,389. *A. J. Dunn, F.R.I.B.A., Clarendon Chambers, Waterloo Street, Birmingham. Dated March* 12/19.—In accordance with this invention, which is a development of Patent No. 122,866, metal connections are partially enclosed in the pre-cast beams and project from them into a space left by the omission of, or removal of, a portion at the end of the cog or fillet projection of the beam. Metal connections are then made from these projecting portions.

The metal connections partially embedded in the concrete members may conveniently be formed of hook-like parts of metal which are partially exposed at the ends of the members to be joined and form anchored loops which facilitate handling the heavy members by lifting tackle, and further enable connecting links to be attached to connect the members across joints; various forms of connecting links and parts are described in detail.

In the first form of connection between reinforced beams (*Figs.* 1 and 3), at each end of each beam (*a*) a cross-bolt or cross-member (*b*) is provided, over which the reinforcement in the beam may conveniently be tied. On to this bolt (*b*) hook-like members (*c*) are anchored, which are moulded in the beam to leave a part or loop of the hook exposed above the surface of the beam. Preferably the beam is cogged as set forth

Fig 3

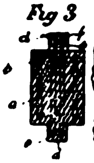


Fig 1

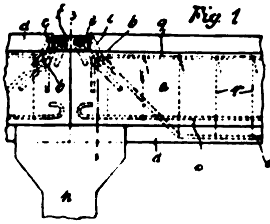


Fig 4

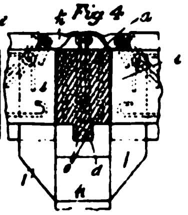


Fig 2

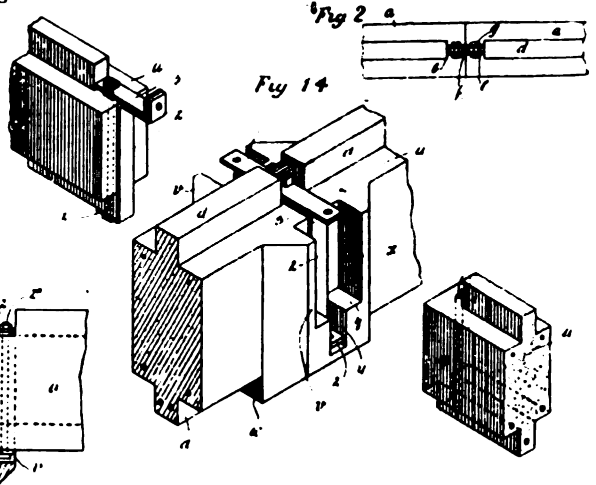
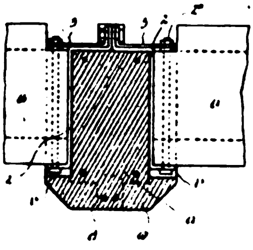


Fig 14

Fig 15



in Specification No. 122,866, and the hook is of S shape, one hook being engaged around the said bolt and moulded in the beam and terminating in the cog (*d*), and the other hook having its loop projecting above the beam where the cog is omitted just short of the end of the beam as shown at (*e*), while the end of this hook is embedded in the beam. Thus at each end of the beam is an eye or loop (*e*) which is convenient in hoisting and erecting the beam, and when the beam is in place by connecting adjacent loops or eyes by side plates or links (*f*) and cross-bolts (*g*) through the plates and the eyes (*e*), adjacent beams are connected in a square manner. The eyes, side plates and bolts may be arranged so as to come within the width of the cog (*d*) or the beam, and of a height below the height of said cog, and when complete may be grouted in to complete the cog and protect the metal connection members.

Where two beams are joined in this way, say above a stanchion (*h*), and two cross-beams (*i*) are brought on to extensions (*j*) of the head of the stanchion and against the sides of the aligned beams (*a*), the cross-beams may be connected by an arched link or twisted plates or strips (*k*), bolted through the eyes (*e*) or loops projecting from the beams as before. The arched link or twisted plates (*k*) cross over the other connection (*f*), and preferably all these parts are constructed of a size to come within the normal dimensions of the cogs (*d*) of the beams, so that when grouted in the cogs are completed.

In connecting main beams (*a*) and secondary beams (*u*, *Figs*. 14 and 15), the main beams are provided at one or both sides with a lateral projection (*v*) which may be bevelled off at the sides to meet the plane surfaces of the beam (*a*), and at the bottom to meet a stiffening block (*w*) flush with the bottom of the bottom cog (*d*) of the beam.

In the projection (*v*) is a recess or pocket (*x*), and in this pocket a narrower recess (*y*) is formed at the bottom to take the bottom cog (*d*) of the secondary beam (*u*). The recess (*y*) leaves two shoulders or chair parts (*z*) for the side parts of the secondary beam to rest on.

A bolt-hole (1) is cored in each secondary beam (*u*) near the end passing up through the cog and the beam to the upper surface, where the upper cog is stopped short as in the other examples of beam connections. Metal stirrups (2) are provided, one for each secondary beam end, each stirrup having a cranked part to pass under the bottom cog, where such part is bolted by a vertical bolt (2*a*) passing through the cored hole in the secondary beam end and secured by a plate (3) and nut at the top. This cranked part is received in the bottom recess in the pocket. Then the stirrup has a vertical part between the secondary beam end and the back of the pocket, and at the top an oppositely cranked portion passing over the top of the pocket and over the main beam to the centre where the upper cog is cut away or omitted, and here the stirrup is cranked again into a vertical end for bolting to the complementary part of the stirrup (2) from the secondary or subordinate beam on the other side of the main beam.

**Concrete Floors.**—*No.* 144,394. *H. Addison,* 7, *St. Catherine's Road, Bitterne Park, Southampton. Dated March* 14/19.—According to this invention, the floors consist of floor slabs laid on supporting beams or walls, both slabs and beams being formed by keying concrete or like plastic material to grooved boards and reinforcing the concrete by expanded metal. In the case of slabs, the boards form the upper surface and are tongued and grooved together; the concrete forms the ceiling surface and is reinforced by horizontal and vertical strips of expanded metal. The beams are formed by casting concrete between two side boards having horizontal grooves on their inner faces, and the concrete is reinforced by a central vertical sheet of expanded metal.

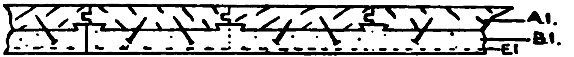


FIG.1

FIG.1A

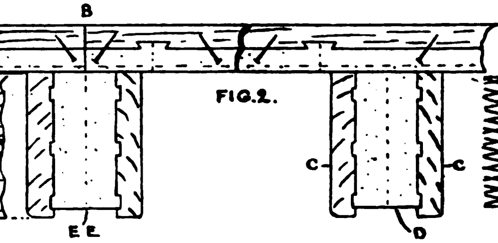


FIG.2.

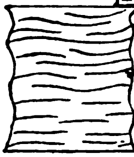


FIG 2A

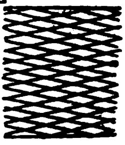


FIG.2B.

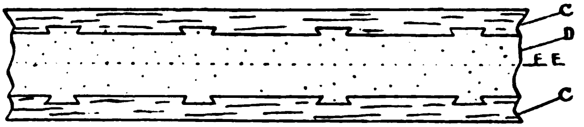


FIG.3.

# CONCRETE IN THEORY — AND PRACTICE. —

*A practical section especially written for the assistance of students and engineers, and others who are taking up the study of reinforced concrete, or who are interested in the subject on its educative side.*

## REINFORCED CONCRETE SIMPLY EXPLAINED.

**By OSCAR FABER, O.B.E., D.Sc., etc.**

*In this series of articles it is proposed to keep explanations so simple as to be intelligible to anyone desiring to understand the underlying principles of reinforced concrete without wading through a lot of mathematics. The results will be accurate and will agree with L.C.C. regulations, but will be more easy to understand. The articles should also form an excellent introduction to those who will need to follow them up with a more advanced work.—ED*

### CHAPTER IV.—*continued.*

*Shearing Resistance of Concrete Beams.*

61. It was explained in Section 58 that the safe shear across a beam having no shear reinforcement is the tensile strength multiplied by the cross-sectional area, and it was shown that failure occurred by *tension on a diagonal plane.*

Suppose now the shear developed in this way is insufficient, we must clearly add steel so as to add to the tensile strength across this diagonal plane.

62. This is best done by *bending up* some of the main tension rods at 45°, so as to cut the weak planes at right angles; clearly the planes cannot then fail without breaking the steel in tension also. [See *Fig.* 10 (*a*) and compare it with *Fig.* 9 (*a*).]

Now if $A$ is the area of the *bent-up bar* (or bars, if several are bent up together), $t$ the safe stress, then $T=At$ is the tension in the bars.

The vertical component, which is the part available for resisting shear, is thus multiplied by

$$A.t.\frac{bc}{ac}$$ [see *Fig.* 10 (*b*)],

where *abc* is a right-angled triangle with *ac* drawn in the direction of the bent-up rods, and *bc* drawn vertical.

This ratio $\frac{bc}{ac}$ is called $\sin\theta$ in trigonometry, so that the shear resistance of bent-up rods is $S=A.t.\sin\theta$.

$S=A.t.\frac{bc}{ac}$, for those who prefer it.

When the bars are bent up at 45°, the ratio $\frac{bc}{ac}$, or $\sin\theta$, is $\frac{1}{1{\cdot}414}$, so the shear resistance is about ·7 the tensile strength of the rods.

63. The student may be tempted to consider that the shear resistance is the sum of the shear resistance of the concrete and that of the bent-up steel.

This, however, is wrong, as will be seen from the following.

It was shown early in this series that when steel and concrete are stressed together, the stress in the steel will be about fifteen times the stress in the concrete.

Clearly, then, when the steel is stressed to 16,000 lb. per square inch, the concrete will be stressed to something over 1,000 lb. per sq. inch. But its tensile strength (breaking) is only about 240.

Hence it follows that before the steel becomes effective, the concrete will have cracked, and lost its tensile strength.

This is the reason why, if the concrete is insufficient to carry the shear, enough steel must be provided to carry the whole shear, and the concrete ignored.

This, however, does not apply to a form of shear resistance called "direct inclined compression," which will be referred to later.

64. Another method of strengthening the weak tension planes is by the use of *vertical stirrups*, as in *Fig.* 10 (*c*).

These may be of different forms, but consist essentially of vertical tension members between the main tension and compression members of the beam.

Comparing *Fig.* 10 (*c*) with 9 (*a*), it will be clear that the *stirrup* will have to carry the *whole shear* when the concrete cracks on the tension plane at 45°.

If the stirrups are further apart than *a*, the depth of the beam from centre of tension to centre of compression, a tension plane at 45° can be drawn with no stirrup cutting it.

Hence it is a rule, that *stirrups must*

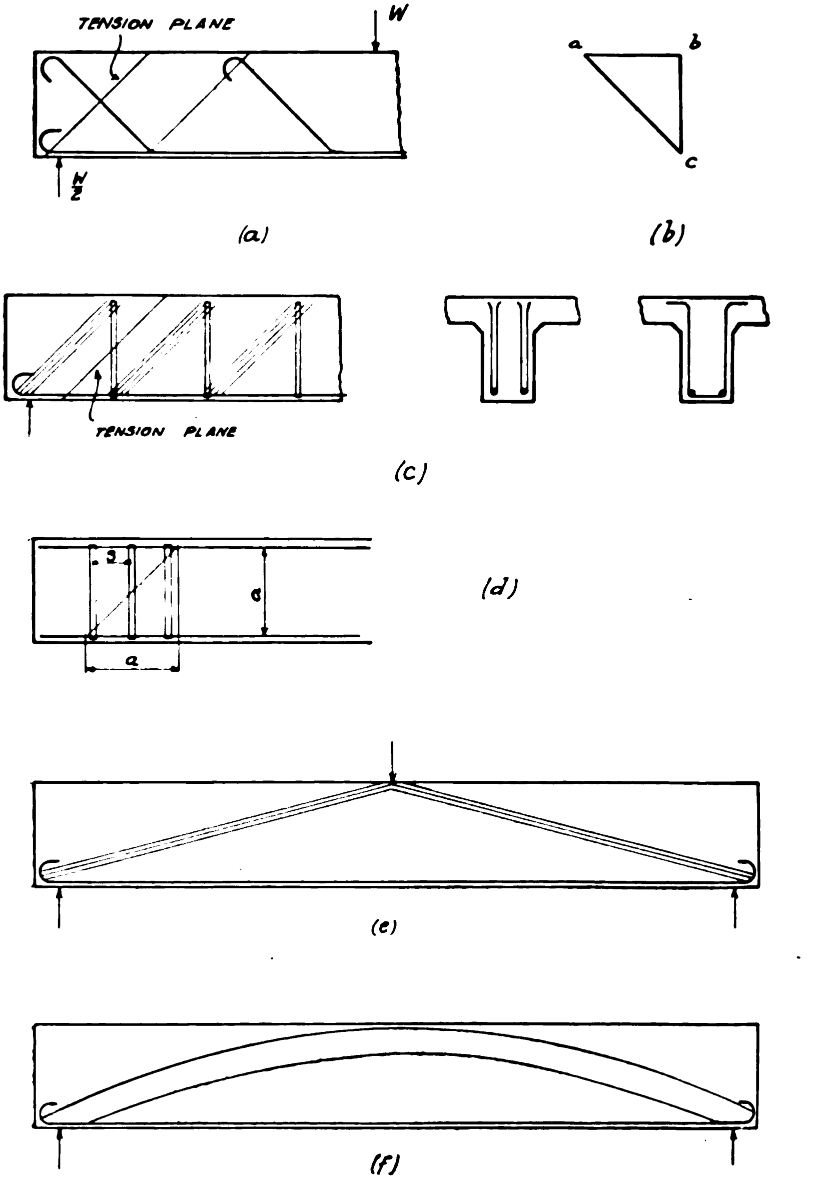


Fig. 10. To illustrate Shear in Reinforced Beams.

*not be further apart than the effective depth of the beam*, or, at any rate, their strength must be ignored if they are so.

On the other hand, if they are closer, any plane at 45° will cut more than one, and the strength will then be proportionately greater.

If $A$ is the area of a stirrup and $t$ the safe tensile stress in it, then $tA$ is the safe tension in the stirrup.

If they are spaced a distance apart $= s$, there will be $\frac{a}{s}$ stirrups crossing a plane at 45°, and therefore the resistance to shear will be

$$S = t.A.\frac{a}{s}$$

where $a$ is radius arm or the effective depth of the beam, and $s$ the spacing of the stirrups.

As before, the resistance of stirrups must not be added to that of the concrete, though it may be added to that of any bent-up bars which may occur across the same tension planes.

The action of stirrups may also be represented as a kind of lattice girder or truss, the stirrups forming the vertical tension members, and the concrete the diagonal compression members, as illustrated in *Fig.* 10 (*c*), the concrete being, of course, well adapted to act in this manner. This treatment leads to the same results as that given.

65. Any beam having tension bars from end to end forms a kind of arch or truss as indicated in *Fig.* 10 (*e*) or (*f*), the concrete forming the inclined compression members.

Such an arch or truss is naturally the stronger when it is not too flat, and hence we find that the strength, or resistance to shear, depends on the ratio of the span to the depth of the beam.

The author has investigated this in great detail, both experimentally and theoretically, and has arrived at the following results:—

SHEAR RESISTANCE FROM DIRECT INCLINED COMPRESSIONS.

| $\frac{\text{Span}}{\text{Depth}}$ $\frac{l}{d}$ | Safe Shear Resistance lb. per square inch. |
|---|---|
| 4 | 122 |
| 8 | 61 |
| 10 | 49 |
| 20 | 24½ |
| 30 | 16·2 |
| 40 | 12·2 |

This table is for uniformly distributed loads. The shear resistance given applies *at the end*, and gets proportionately less as the centre is approached and the arch gets flatter.

In the case of concentrated loads at midspan, half the values in table apply, but the resistance is then constant throughout the span.

The *steel carried through from end to end* must not be less than ·675 per cent. of the area of the concrete in the beam, or in the web or rib of the beam when it is a T beam for the above values to apply.

It is also essential that such steel shall be well secured at the ends, otherwise the arch may spread.

Occasionally, where more steel is used, higher values may be developed (up to 50 per cent. increase), but this will not be gone into here as it is not simple.

The following rule gives, near enough, the same results as the table, and is more convenient for intermediate values.

*Safe shear resistance (from direct inclined compressions) is* 500 *lb. per sq. inch, multiplied by ratio of effective depth to span for uniform loads, and by effective depth to twice the span for concentrated loads at midspan.*

The important point about this *shear resistance by direct inclined compression* is that it may be added to that due to stirrups or bent-up rods, since it does not depend on the tensile strength of concrete.

Examples will be given in the succeeding sections.

# CEMENT NOTES.

### A New Revision of the British Standard Specification for Portland Cement.

THIS issue of the British Standard Specification for Portland Cement, dated August, 1920, constitutes the fourth revision in sixteen years, and is an indication of the development of the industry and the growth of knowledge. The modifications appearing in the latest revision are :—

(1) An addition to clause 1 expressly excluding slag as an adulterant. (2) An addition to clause 4 providing for the sampling of cement when stored in deep silos. (3) Exclusion of the specific gravity test. (4) A modification of clause 7 dispensing with aeration of the sample before testing for setting time. (5) A modification of clause 9 dealing with the calculation of the proportion of lime to silica and alumina. (6) A radical alteration of the limits for setting time imposed by clause 12. (7) An alteration to clause 15 providing that the purchaser of cement can only require a free certificate of quality if demanded at the time of purchase.

The *alterations to setting time* are of considerable importance to the cement user. In the preceding issue of the specification (1915), three degrees of setting time were provided for, viz., quick setting—a cement needed for sub-aqueous or tidal work; medium setting—generally useful for plastering and pipe jointing; slow setting—suitable for all ordinary work and essential for reinforced concrete. The medium setting grade has disappeared from the new specification, and there remains only one grade with a minimum initial set of twenty minutes and a maximum final set of ten hours. If a specially quick setting cement is required, the minimum initial set is two minutes, and the maximum final set is thirty minutes.

A purchaser of cement is thus liable to be supplied with cement that may take any period from one hour (corresponding to an initial set of twenty minutes) to ten hours to set hard. The cement from an individual manufacturing firm would not be subject to any large variation in setting time, but when ordering from a fresh manufacturer or merchant the purchaser would not know, until he came to use the material, whether he had been supplied with a cement which needed celerity in mixing and deposition, or one which was so slow in setting as to require careful protection from frost, sun and wind for a prolonged period. Obviously a cement with setting properties near to the quicker setting margin of the limits would not be suitable for certain reinforced concrete work, while cement of nine or ten hours final set would be unsuitable for plastering or pipe jointing.

This change in the specification thus seems likely to strengthen the bond between cement users and their favourite brands, but buyers of cement from fresh sources would be well advised to inform the manufacturer if the cement is to be used for any of the special purposes that have been mentioned.

Another change in the specification of interest to the cement-user, is the *removal of the specific gravity test*, and this will be welcomed by manufacturers, not because of any relief to the process of manufacture, but because the specific gravity is a property of cement particularly susceptible to alteration with age, thus becoming beyond the manufacturer's control after the cement leaves his possession.

Cement in contact with the atmosphere, whether in sacks or in bulk, absorbs moisture and carbonic anhydride, and in so doing the specific gravity is proportionately reduced. All cements of normal composition have a specific gravity of 3·18, if free from water and carbonic anhydride, but there is a continuous reduction as the cement absorbs these constituents from the atmosphere, until at last when the proportions exceed 2 per cent. the specific gravity is liable to fall below 3·10, the limit imposed by the previous specification. Conversely, the specific gravity of all cement which has been exposed, can be increased to 3·18 by the application of heat which drives off the moisture and carbonic anhydride.

Hence, provided the cement was normal in other respects, the specific gravity was merely an indication of the amount of water and carbonic anhydride contained, and the user was already protected against any undesirable excess of these constituents by the provision of the specification which limits the loss on ignition to 3 per cent.

The specific gravity of cement was at one time thought to indicate the degree of burning, but this idea has been disproved by investigators, who have shown that a palpably underburnt cement had a specific gravity equal to a well-burnt material so long as it was free from water and carbonic anhydride. When the relation between specific gravity and burning was shown to be fallacious, the test was retained with the idea that it aided in the detection of adulteration. The majority of adulterants of Portland cement have a lower specific gravity, and any appreciable addition would cause the mixture to have a specific gravity below 3·10. This, however, would not be an infallible method of exposing adulteration, because it would be quite possible to adulterate cement with 10 per cent. or more, of some materials, without reducing the specific gravity below 3·1, although such adulteration would be detected by chemical analysis.

For example, natural cements, i.e., cements produced by calcining natural calcareous rocks without the preliminary mixing prescribed by the specification, are liable to have low specific gravities, but such cements are far more readily detected by a chemical examination than by the specific gravity test. Similarly, slag cements frequently have low specific gravities, but again a chemist has more delicate means of revealing the nature of such a cement without determining the specific gravity.

It is evident that the fallacies associated with the specific gravity of cement have now been officially recognized, and the Engineering Standards Committee is to be congratulated on abandoning a test which was no safeguard to the user and anomalous from a scientific standpoint.

### Portland Cement for Pipe Jointing.

The use of Portland cement for pipe jointing is probably one of the most delicate to which cement is put, and is consequently productive of more complaints than any other cement work. The usual difficulty arises from the contraction cracks that are liable to form and lead to leakage of the joint when the pipe line is tested under pressure. Such contraction cracks do not imply a defective cement, but are due to the too rapid evaporation of the water mixed with the cement to form a paste.

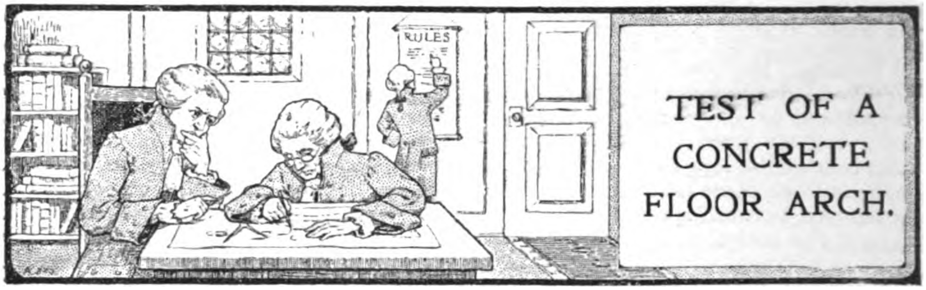
A paste of cement and water cannot be produced with less than about 22 per cent. of the latter, but little more than half this amount is absorbed by the cement in setting, so that the balance of the water is dissipated by evaporation. If the evaporation takes place while the cement is still soft the latter is unable to resist the formation of contraction cracks and fissures, but if the evaporation can be prevented until the cement is hardened, such cracks do not occur.

There are two roads to success in pipe jointing, and the most important is the prevention of too rapid drying of the joint by some effective protection from sun and wind. The means of protection which naturally suggests itself is a damp sack, although this method does not commend itself to the cement manufacturer who is owner of the sack.

The tendency to crack can also be minimized by using a mixture of equal parts of cement and sand instead of neat cement, because with such a mixture there is less tendency to contraction than with neat cement. There need be no fear that the addition of sand in the proportion mentioned will not produce a watertight joint, but it is essential that the sand should be free from clay or loam and fairly fine in grain.

In view of the fact that the cracking of pipe joints is caused by contraction during setting, it follows that the risk is increased when a slow setting cement is employed, and the ideal final setting time for this work is between one and two hours. Some manufacturers cater for pipe jointing requirements by supplying a cement with such setting properties. There is also an attempt occasionally made by pipe jointers to produce this setting time by mixing washing soda with the gauging water, but this is to be deprecated, because the proportion of soda necessary for the purpose varies with every cement and can only be determined by careful experiments, otherwise there is the risk of the cement being made too quick setting, and then the jointer is compelled to break through the initial set and so delay the final hardening.

If the pipes to be jointed have any tendency to porosity through damage or otherwise, the ends should be well soaked with water before jointing to prevent water being absorbed from the cement.

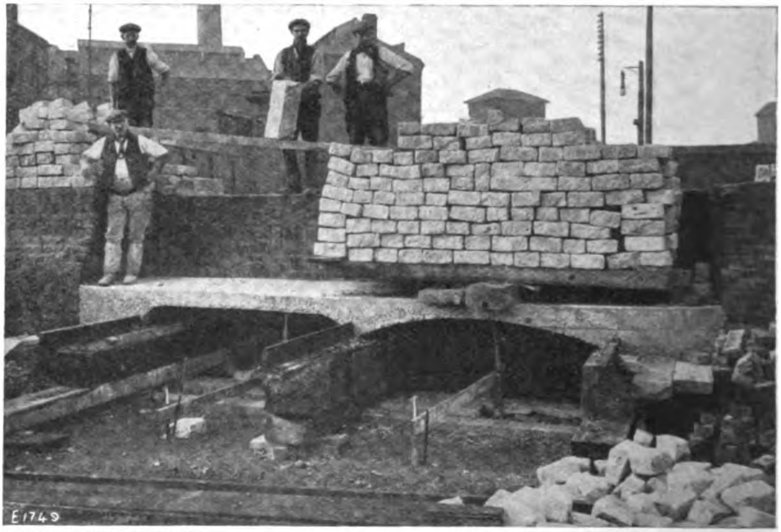


# TEST OF A CONCRETE FLOOR ARCH.

*By the courtesy of "The Engineer" we are able to publish below some interesting particulars and illustrations regarding a test on a Concrete Floor Arch.—ED.*

THE object of test was to determine if it was suitable for the construction of a floor subject to rather severe conditions, and in view of the fact that the mode of building is somewhat novel, some of the results of the experiment are given below.

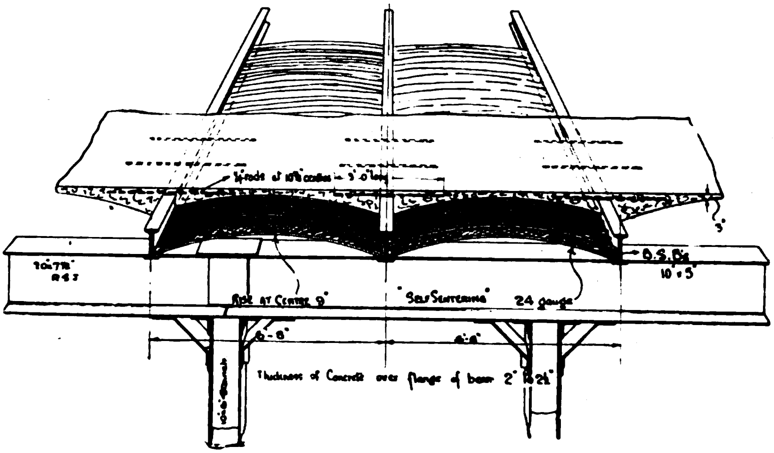
The floor in question is for the extensions of the Colthrop Board and Paper Mills at Thatcham, Berks, for which Mr. Worby Beaumont is acting as consulting engineer, and will have to carry an American type of beating machine in which the floor forms itself part of the bed. The resultant load will amount to about 5 cwt. per square foot, but the floor will also have to withstand the concentrated load consequent on one of the rolls, which weigh 5 tons, being taken out of the machine and set down alongside.



From "The Engineer."]
FIG. 1. EXPERIMENTAL ARCH, LOADED WITH 13 TONS.

The sketch *Fig.* 2 shows the general proportions decided upon for the floor, which, it will be seen, will be of normal design in so far as the framing is concerned. The concrete arches of the floor itself, however, are not to be formed on wooden shuttering, but by using the reinforcing metal as the form. This metal is supplied by the Self-Sentering Expanded Metal Works, of 110, Cannon Street, London, E.C.4, and is a development of the familiar form of expanded metal. It is made of comparatively light steel—from 28 to 24 gauge—with a fine mesh and deep V-shaped longitudinal ridges of unexpanded sheet protruding upwards at intervals of every few inches. These sheets are cut to the requisite length and curved at the makers' works. They are slipped in place between the joists of the floor as shown in *Fig.* 2, where the first sheet is shown in perspective from above, and the further sheets covered with concrete. In the case of wide spans it is sometimes necessary to put a temporary support under the centre of the arch, but otherwise the concrete can be placed directly on the metal without further preparation. The concrete is, naturally, mixed with such a consistency that it will not flow too freely through the openings of the expanded metal, and it is surprising how little actually does get through in practice.

The great merit which is claimed for this system of construction is the small amount of skilled labour required. Carpenters are not needed and almost any labour can be employed to set the Self-Sentering in place. The whole of the floor can be prepared at one time and then, by laying boards across the joists for barrow runs or setting up one of the modern distributing shoots, the concrete can be laid as fast as it is mixed. There is no need to wait while one section of the floor sets and the shuttering can be released for re-erection on another section. Another important consideration is the saving in cost which can be effected. From figures supplied to us by the makers it appears that the Self-Sentering is actually cheaper than wooden shuttering, assuming that the shuttering is used five or six times before it is worn out, and that a saving of several shillings per square yard of floor can be made. Incidentally the metal provides some degree of reinforcement to the concrete and offers a good key for plaster if it is desired to finish the underneath surface.


¼" rods at 10½" centres – 3' 0" long
10" × 7½" R.S.J.
O.S. B's 10" × 5"
3"
Rise at Centre 9"
"Self Sentering"
24 gauge
6'-8"
6'-8"
Thickness of Concrete over flange of beam 2" to 2½"

From "*The Engineer.*"]

FIG. 2. SKETCH OF PROPOSED CONCRETE FLOOR.

This type of floor appeared to be quite satisfactory for the paper mill mentioned at the commencement of this article, but before finally deciding upon its adoption Mr. Worby Beaumont asked for some tests of its strength.

A site for the trial was found at the back of King's Cross Station, where Sir Robert MacAlpine and Co. have a contract in hand, and the arrangements were made by Mr. William Sharp, of 11, St. Pancras Lane, London, E.C.4. Two massive abutments projecting from a heavy wall bordering the Regent's Canal were pressed into service, and the two spans, shown in the sketch *Fig.* 2 and in *Fig.* 3, were built between them. It will be noticed that the two spans are of different design. That on the left

**Reinforced Concrete Beams.**—*No.* 144,193. *Walter Wilson, South Dewar Street, Dunfermline. Dated April* 22/19.—According to this invention, which is an improvement upon that described in Patent No. 103,681, the reinforcing wires, cables, etc., are held at tension between frames located at the ends of the mould and provided with removable cross-rods with sleeves thereon, on or about which the wires, etc., are stretched.

Each end frame, as shown, comprises a pair of angle-irons spaced apart to suit the width of the mould and bent up to form uprights (1) and base flanges (2), which may be strengthened by ties (3). The mould is completed by side boards (*D*) and end boards (*D*) erected between the uprights (1). The angle-irons are adjustably secured at the ends of the mould by means of bolts (4) which are fixed in the foundation and pass through elongated openings (5) in the base flanges (2).

The uprights (1) of each end frame are provided with a corresponding number of openings adapted to receive cross-rods (6) on which sleeves (7) are mounted between the uprights. The main reinforcing wires, or cables (*C*), are connected to the sleeves (7) at each end of the mould and are stretched and tensioned by means of screw couplings or otherwise.

For the purpose of subjecting one or more of the reinforcing wires or cables to additional tension, side frames (8) are or may be provided. Each side frame (8) is secured to the foundation (*A*) and has a screw clamp constituted by a sliding block (9) which is attached to a screw (10) threaded in the upper portion of the frame, the screw (10) being provided with an operating handle or hand-wheel (11).

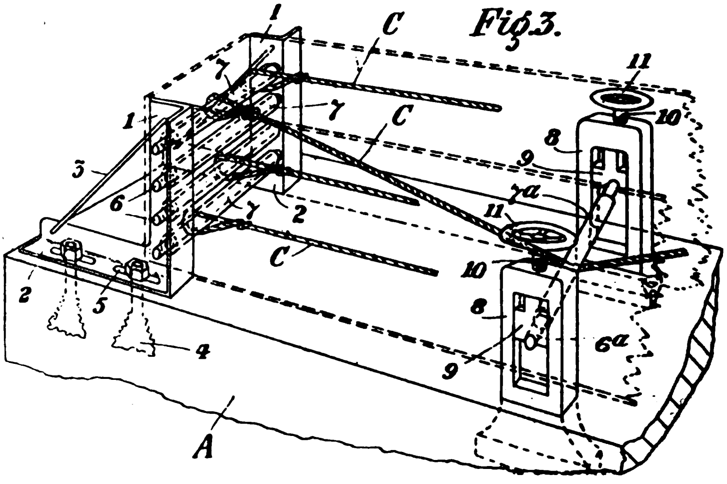


Fig. 3.

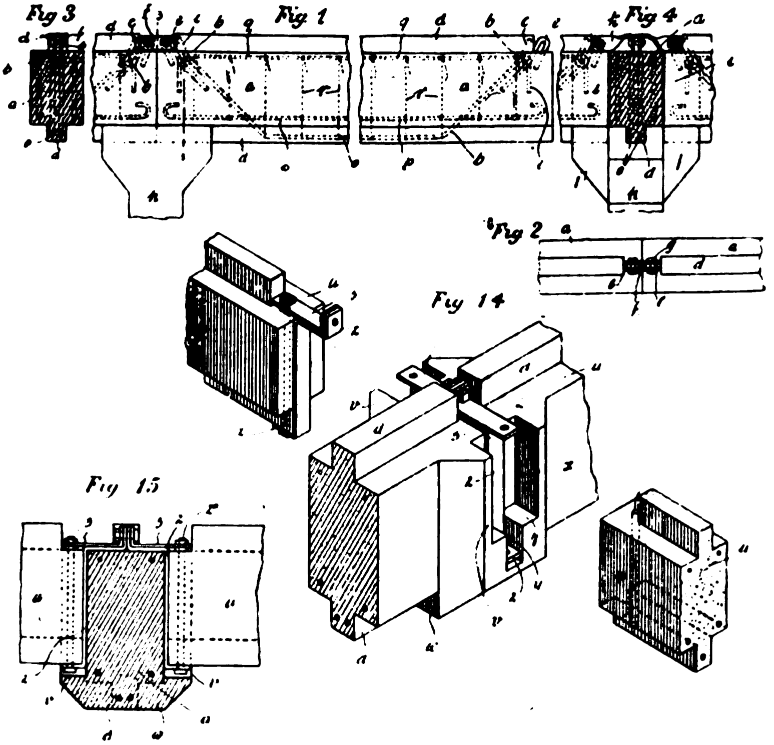
When the concrete is thoroughly set the cross-rods (6, 6*a*) are removed. Owing to the tension of the reinforcing wires the sleeves (7) around which the wires are passed are drawn tightly against the supporting rods (6), but this pressure can be relieved by slackening back the nuts on the foundation bolts (4). The pressure on the cross-rod (6*a*) is relieved by simply screwing back the blocks (9) from engagement therewith, after which the rod can be withdrawn.

After the rods (6, 6*a*) have been removed the beam is taken out of the mould with the reinforcing wires or cables and the sleeves (7 and 7*a*) embedded therein. The sleeves (7 and 7*a*) embedded in the concrete serve as means whereby the beams can be jointed together by fish-plates and bolts.

**Concrete Structures employing Pre-cast Members.**—*No.* 144,389. *A. J. Dunn. F.R.I.B.A., Clarendon Chambers, Waterloo Street, Birmingham. Dated March* 12/19.—In accordance with this invention, which is a development of Patent No. 122,866, metal connections are partially enclosed in the pre-cast beams and project from them into a space left by the omission of, or removal of, a portion at the end of the cog or fillet projection of the beam. Metal connections are then made from these projecting portions.

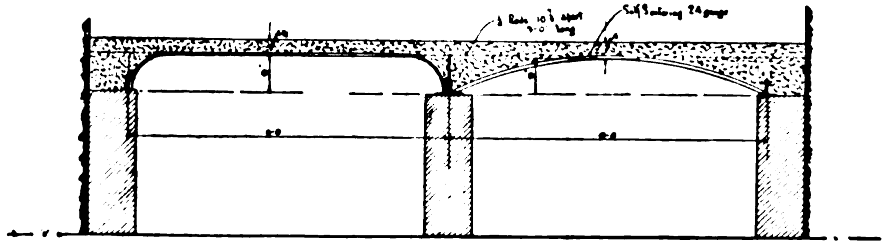
The metal connections partially embedded in the concrete members may conveniently be formed of hook-like parts of metal which are partially exposed at the ends of the members to be joined and form anchored loops which facilitate handling the heavy members by lifting tackle, and further enable connecting links to be attached to connect the members across joints; various forms of connecting links and parts are described in detail.

In the first form of connection between reinforced beams (*Figs.* 1 and 3), at each end of each beam (*a*) a cross-bolt or cross-member (*b*) is provided, over which the reinforcement in the beam may conveniently be tied. On to this bolt (*b*) hook-like members (*c*) are anchored, which are moulded in the beam to leave a part or loop of the hook exposed above the surface of the beam. Preferably the beam is cogged as set forth in Specification No. 122,866, and the hook is of S shape, one hook being engaged around the said bolt and moulded in the beam and terminating in the cog (*d*), and the other hook having its loop projecting above the beam where the cog is omitted just short of the end of the beam as shown at (*e*), while the end of this hook is embedded in the beam. Thus at each end of the beam is an eye or loop (*e*) which is convenient in hoisting and erecting the beam, and when the beam is in place by connecting adjacent loops or eyes by side plates or links (*f*) and cross-bolts (*g*) through the plates and the eyes (*e*), adjacent beams are connected in a square manner. The eyes, side plates and bolts may be arranged so as to come within the width of the cog (*d*) or the beam, and of a height below the height of said cog, and when complete may be grouted in to complete the cog and protect the metal connection members.



Where two beams are joined in this way, say above a stanchion (*h*), and two cross-beams (*i*) are brought on to extensions (*j*) of the head of the stanchion and against the sides of the aligned beams (*a*), the cross-beams may be connected by an arched was made for a distinct investigation, but the right-hand arch was made as nearly as possible a model of the actual floor. The depth from back to front was nearly 5 ft., and an offset was used on the right to make out to this width from the abutment. The top surface of the arch was practically flat. The concrete was quite free from the wall at the back.

The concrete was taken from a batch mixed in the ordinary course of events for the adjacent works and was a 1:2:4 mix with gravel as the aggregate. It was placed by ordinary labourers without any special supervision. After the concrete had set for five weeks a layer of granite setts representing a load of 5 cwt. per square foot was spread over the two arches and was almost immediately increased to 7 cwt. per square foot. The load was then taken off the left-hand span and that on the arch further increased, but no signs of failure were seen. The gauge which was rigged up under the arch to measure deflection, and can be seen in half-tone engraving, was not very satisfactory, but it was evident that the load was not distressing the concrete at all.



*From "The Engineer."*]

FIG. 3. SECTION THROUGH TEST SPANS.

The granite setts were left on the arch for some time, and then, at the end of about twelve weeks, were rearranged to form a concentrated load as shown. The outside measurement of the two timber baulks carrying the load was 2 ft. 3 in. and the space between them 3 in. wide. When the total load had been brought up to 7 tons a faint crack appeared in the crown of the arch on the underside and the gauge showed a deflection of less than a sixteenth of an inch. The load was then increased until it amounted, according to measurement, to just over 13 tons, when the photograph which we reproduce was taken. At this stage the weight carried was over 2½ tons per foot run of the arch, but no further cracks developed, and it was decided that it was unnecessary to increase the load any more. With the idea, however, of trying if a violent vibration would affect the arch when loaded, a granite kerbstone weighing some 3 cwt. was dropped several times on the adjacent slab. In the illustration the stone is shown after it had broken in half after the second fall, ready to be tipped over again. Neither of the two arches was hurt in the least by this rough treatment.

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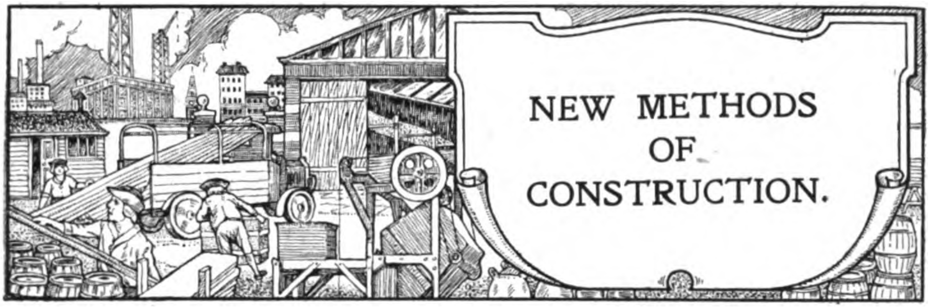
## MEMORANDUM.

**Strengthening Concrete Piles by Explosive Charge.**—In connection with the article appearing in our November number (page 760), Messrs. The Considère Construction Co., Ltd., remind us that the idea of obtaining additional resistance for reinforced concrete piles by expanding their points, as set out in the above-mentioned article, was first suggested by M. Considère in 1912 and covered by his Letters Patent. In this case, however, a pre-cast pile was used, and the void at the toe formed by the explosion was filled in with cement grout, introduced through a tube cast in the centre of the pile.



# NEW METHODS OF CONSTRUCTION.

*In recent issues we have given a list of new methods of construction which have been passed by the Ministry of Health in connection with housing schemes, and so that our readers may have fuller particulars of these methods, we propose publishing some further information regarding same, based on details supplied to us by the different firms putting forward new methods.—ED.*

## HAYES SYSTEM OF CONCRETE CAVITY WALLING.

THE system here described has been devised with the object of overcoming some of the difficulties at present encountered in the supplying of houses, and to meet immediate demands owing to the shortage of skilled labour. It is primarily intended for use in the construction of dwellings, although its scope may be considered to cover a wider field.

The method here under review is a system of concrete construction with the concrete moulded *in situ* together with a simple and easily erected form of shuttering which will afford an opportunity for the utilization of unskilled labour.

In the " Hayes System," concrete walling with a 2-in. continuous air cavity has been adopted to overcome the objections to the possibility of condensation on the inner face of concrete when used in solid walls.

A simple form of shuttering has been devised together with special wall ties which not only tie the two portions of the wall together but also act as supports for the shuttering during construction. The iron wall ties are dipped in a special preparation to protect them from any chemical action which might otherwise take place when clinker is used as an aggregate.

The shuttering consists of two external lines of timber shuttering 2 ft. in height, reinforced with specially designed straps and to which are hinged clamping bolts for holding the tops of the shutters in position and having angle struts attached to enforce perpendicularity. The shuttering for the 2-in. cavity consists of pressed steel shutters, with wedge-shaped ribs to facilitate striking, arranged in pairs, and a boss formed on the hinged tie bolts of the timber shutters engages with the cavity shutters to hold them vertically in position and to the required gauge.

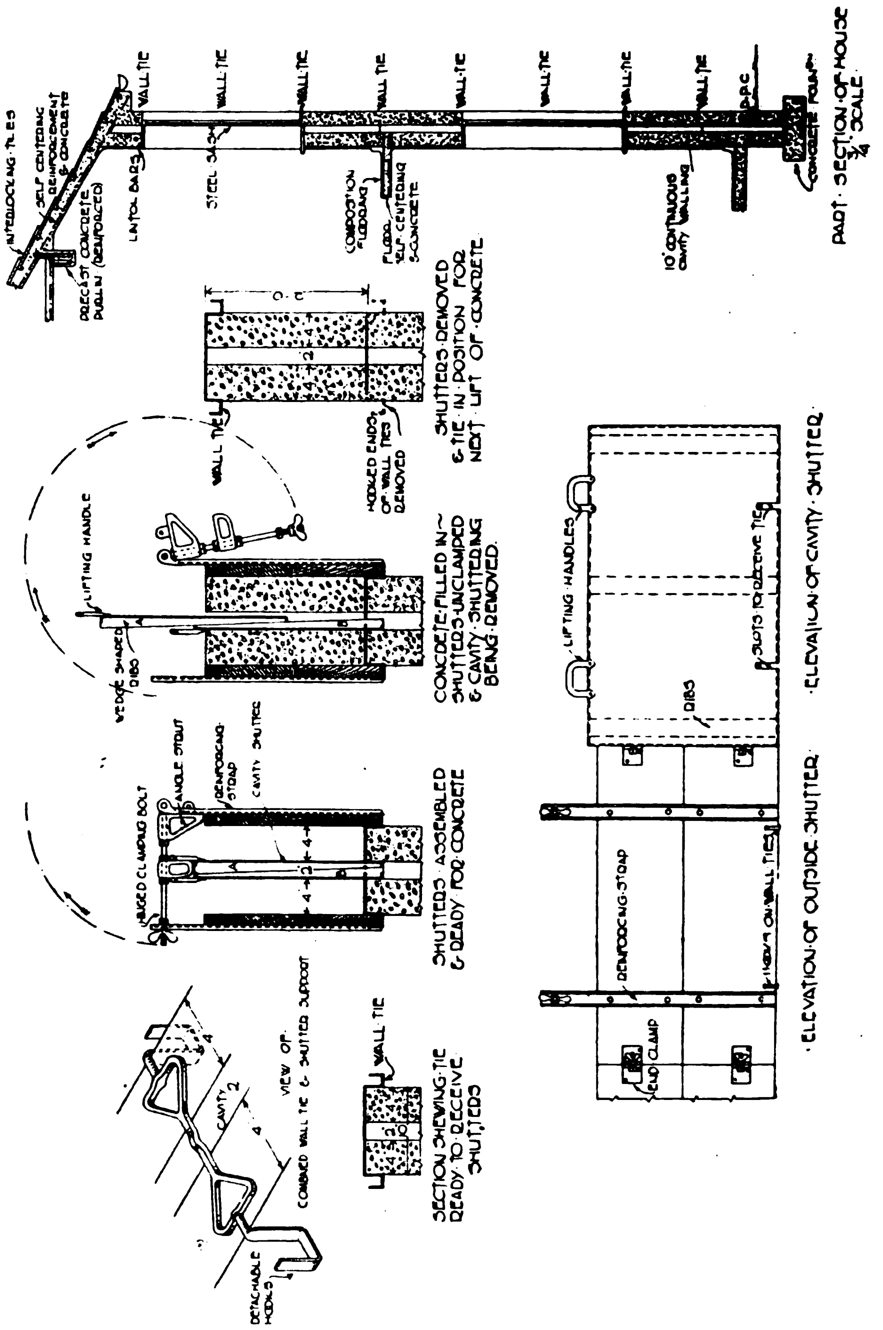
The illustration shows 4-in. external and 4-in. internal walls with a 2-in. cavity, giving a total thickness of 10 in. over all, although the shutters can be used for various thicknesses of walls by adjusting the boss on the tie bolts, or can be used for solid concrete walling by omitting the cavity shutters.

To remove the shutters after concreting is completed the tie bolts are slacked off and turned back at the hinged joint when the outside shutters can be lifted away and the cavity shutters can be drawn out by means of the lifting handles provided.

The hooked ends of the wall ties provide a support for the outside timber shuttering and are afterwards cut off, detached and re-used. The cavity shutters are slotted and are supported on the wall ties and lap on to the portion of wall previously concreted. The timber shutters are coated with a preservative which also prevents any adherence of the concrete, and thus assures easy removal. The method of constructing is as follows :—

A concrete foundation is laid in the usual manner.

At intervals on this foundation the special wall ties are laid, the shuttering placed on these and clamped in position.


INTERLOCKING TILES
SELF CENTERING REINFORCEMENT & CONCRETE
PRECAST CONCRETE PURLIN (REINFORCED)
LINTOL BARS
WALL TIE
STEEL SASH
COMPOSITION FLOORING
FLOOR SELF CENTERING & CONCRETE
10" CONTINUOUS CAVITY WALLING
D.P.C
CONCRETE FOUNDN
PART · SECTION · OF HOUSE ¾ SCALE
O·C
4
2
4
WALL TIE
HOOKED ENDS OF WALL TIES REMOVED
SHUTTERS REMOVED & TIE IN POSITION FOR NEXT LIFT OF CONCRETE
LIFTING HANDLE
WEDGE SHAPED RIBS
CONCRETE FILLED IN SHUTTERS UNCLAMPED & CAVITY SHUTTERING BEING REMOVED
HINGED CLAMPING BOLT
ANGLE STRUT
REINFORCING STRAP
CAVITY SHUTTER
SHUTTERS ASSEMBLED & READY FOR CONCRETE
VIEW OF COMBINED WALL TIE & SHUTTER SUPPORT
CAVITY 2
DETACHABLE HOOKS
WALL TIE
SECTION SHEWING TIE READY TO RECEIVE SHUTTERS
LIFTING HANDLES
SLOTS TO RECEIVE TIE
RIBS
ELEVATION OF CAVITY SHUTTER
REINFORCING STRAP
HOOKS ON WALL TIES
END CLAMP
ELEVATION OF OUTSIDE SHUTTER

The concrete is then poured in to the full height of the shutters and allowed to set for say twenty-four hours, when the shuttering is removed.

Another line of wall ties is placed on the top of this concrete, the shutters re-erected and concreting proceeds.

These operations are repeated until the height of the first floor is reached.

Pre-cast concrete beams are placed in position and supported on the walls and over these a self-centering mesh-reinforcement is laid and concreted.

The shuttering is again placed on at this level and walling proceeds as before up to eaves level.

The roofing consists of precast concrete purlins and ceiling joists with similar mesh reinforcement and concrete covering as used for the floor. The roof tiling or slating can then be nailed either direct to this concrete or laid on battens.

A typical section through a house with pitched roof is shown and a scheme has also been prepared for a flat roof design.

The internal partition walls are similarly constructed of concrete but with the cavity deleted.

With the type of shuttering described it is possible to use two different gaugings of concrete for external and internal portions of the cavity walls, i.e. a hard or dense aggregate can be used outside to withstand climatic conditions and a more porous concrete used for the inside without fear of cracking due to uneven shrinkage of the two mixtures.

The Building Materials Research Committee in their report state that a 10-in. concrete wall consisting of 4-in. external ballast concrete, 2-in. air cavity, and 4-in. internal coke breeze concrete offered greater resistance to the flow of heat than any other construction of walling either of brick or concrete.

It may therefore be taken that a house constructed with the 10-in. concrete cavity walling referred to will not be affected to any great extent by thermal changes.

Houses of the construction described are fire-resisting and vermin proof, the only timber used being in doors and casings.

The possibility of dry rot is also obviated and upkeep reduced to a minimum.

With four pairs of houses in progress ten men could fix shuttering and concrete the eight houses one foot in height per day with shuttering being lifted on two pairs while the other two pairs are being concreted. Taking the average height of a dwelling as 18 ft., this means that four pairs of houses would be erected in eighteen days or four and a half days for each pair of houses with the ten men employed.

Regarding the shuttering this can be used repeatedly and almost indefinitely as it is subjected to very little wear.

As to the cost of houses constructed on this system a considerable saving can be effected over ordinary methods of construction.

A provisional patent has been granted and the system has the approval of the Ministry of Health.

A contract has been entered into for the erection of six "B" type houses on the above system at Appleton, Widnes, Lancs.

## MEMORANDUM.

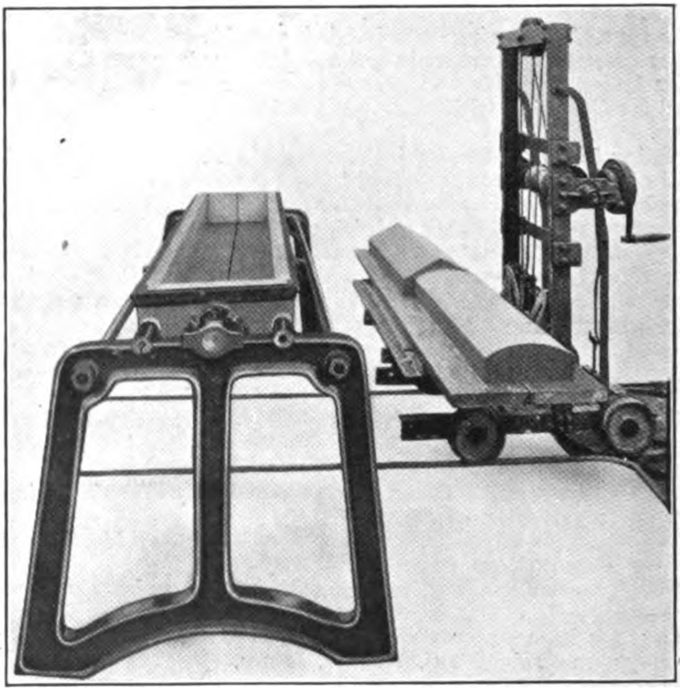
**Concrete Roads.**—The value of the cement concrete roadway, which connects Toronto and Hamilton, is declared by Mr. George H. Gooderham, Chairman of the Toronto-Hamilton Highway Commission, to be of "greater importance than any other section of highway in Canada." On the busiest days the traffic exceeds 8,000 vehicles, the average being about 3,000, and the average motor lorry traffic about 400 per day. Farmers living fifteen miles from the Toronto market who formerly made three trips by team per week by being up early and late now leave home at eight in the morning, are home for dinner and supper, and make twelve trips per week by motor lorries in comfort. Many of the farmers, Mr. Gooderham declares, sell all their market produce at their own gates to the motorist, and some of them six miles off the highway haul it to wayside and community markets which have been encouraged by the Commission.
—*Commercial Motor.*

# NEW CONCRETE MACHINERY.

## A COMBINED CONCRETE BLOCK MAKER AND TRANSPORTER.

We recently had an opportunity of inspecting a new concrete block making machine designed to work in conjunction with an elevator mounted on a bogie, by means of which a considerable amount of the labour required to carry the blocks from the moulding machine to the spot where they are to be stacked for curing is dispensed with. The machine (illustrated herewith) has just been placed on the market by the manufacturers, The Liner (L.C.) Concrete Machinery Co., of Newcastle-on-Tyne, and contains many features of interest.

The inside dimensions of the moulding box are 6 ft. by 13 ins. by 6⅜ ins., and it will turn out slabs of this size, or, by dividing the mould with metal liners, any number of smaller blocks can be made in one operation. Also, by a special attachment, the height of the mould can be increased to permit of blocks 10 ins. deep being made, and by the insertion of cores hollow blocks can be made. The moulding box is mounted on a solidly constructed frame, and is simple in operation. After it has been filled, tamped and floated off a wooden pallet is placed over the top of the box and held in position by clips. The mould is held in a horizontal position by a pin at one end, which, when the covering pallet is fixed, is released and the box turned completely over on a central axis. The elevator, with the platform raised to the required height, is then run under the mould and the clips which hold the pallet which was placed over the top (now the bottom) of the mould are released, thus transferring the block and the loose sides and ends with which the mould is fitted to the elevator platform. The platform is then lowered so that the block is clear of the mould, and backed away ; the false sides and ends are replaced in the mould ready for the next operation, and the block taken away on the elevator to be stacked.



"Liner" Concrete Block-making Machine and Transporter.

On the stacking ground trestles are provided to which the pallets containing the blocks are transferred by raising the elevator platform and then lowering it and backing the elevator clear of the trestles. The elevator will lift a load of 4 cwt. to a height of 4 ft. 6 ins., thus enabling the blocks to be stacked in tiers three high, with a consequent reduction in the area of ground required for curing purposes. The mould, elevator and lengths of narrow gauge track are supplied as a complete unit, including a turn-table in the track by which the elevator can be turned so that it arrives at the mould or the stacking ground with the platform foremost.

An interesting feature of the moulding box is that the liner which runs lengthwise, when used, is withdrawn through the bottom of the box, thus obviating any possibility of the face edges (the blocks are made face down) being damaged by the concrete adhering to the liner. Only three men are required to operate the complete plant—two to fill the mould and tamp it and one to push the elevator. The elevator is mounted on ball bearings, and a boy can easily push it and operate the raising and lowering gear with a block weighing 4 cwt. on the platform. The use of the track and turn-table opens up a wide sphere of possibilities in the saving of labour ; for instance, in the erection of a row of houses the mould could be placed at one end and a track laid completely round them. By this means, the blocks for each house could be stacked within a few feet of where they were wanted, and the delays and expense of double handling dispensed with. At the demonstration the complete operation of filling the mould, tamping and floating the concrete, fixing the pallet, turning the mould and transferring a block to the elevator platform was performed in three minutes.

## MEMORANDUM.

**Presaturated Sand Facilitates Concrete Mixing.**—An interesting account was given in the *Engineering News Record* of wetting the sand used in concrete to the point of saturation. This method was adopted in the construction of the Taylorsville dam in connection with the Miami flood protection works, and it is claimed that constancy of mortar volume and increased speed and smoothness in mixing are secured in this way. Water is added to the sand until it contains all that it will retain by capillarity. This procedure combined with excavation from different parts of the pit as a finer or a coarser mixture is wanted is standardizing very successfully a washer product where the pit materials run irregular.

The structure requires about 55,000 cu. yd. of concrete mainly in massive walls and floor slabs.

Tests of the local gravel at Taylorsville demonstrated that the most dense gravel mixture was obtained by combining equal parts of coarse (1½ to 3-in.) gravel and of small (1¼ to 1½-in.) gravel. Further tests to determine the volume of sand which would, with the gravel mixture, give the most dense combined mixture, disclosed the facts : (1) That sand as drawn from the washed sand bin contained varying amounts of moisture ; (2) that varying amounts of moisture in the sand gave varying volumes of mortar per measure of sand, and (3) that sand saturated with water gave a constant volume of mortar and also, with the gravel mixture, the most dense combined mixture. Considering a 1-cu. yd. mixer batch, 16-cu. ft. of coarse gravel and 16-cu. ft. of small gravel and 13-cu. ft. of saturated sand gave a 30½-cu. ft. batch. This was the minimum volume which could be secured by any combination and was adopted as the standard working mixture.

To saturate the sand, water is run into the measuring chute, a prescribed quantity determined by experience being admitted. The final adjustment of water in the concrete is made by jetting water into the mixer until the desired consistency, judged by the eye, is secured.

The use of the saturated sand has practical advantages besides that of keeping the mortar volume constant. The charge flows more easily into the mixer and the materials mingle more readily. The mixing process is more rapid. The newly charged material has less tendency to ride up the rising side of the mixer and to spill out. Since danger of loss by spilling is lessened the size of the batch can be increased. For example, in placing 3,000 cu. yd. measured in the forms, the 1-cu. yd. mixer averaged 1·2 cu. yd. per batch.

# NEW BOOKS

## AT HOME AND ABROAD.

*A short summary of some of the leading books which have appeared during the last few months.*

**The Practical Design of Plate Girder Bridges. By H. H. Bird.**
C. Griffin & Co., Ltd. Price 15s.

This book deals principally with the design of Railway Bridges and endeavours in this respect to bridge the gap between the theoretical training a student receives at college and the practical design which he is expected to do later. The portions which attracted us most were the excellent sketches of details, such as the waterproofing and protection of bridges, provision for dealing with rain, provision for inspection and painting, and practical matters of this kind. In regard to the actual design, though everything appears to be clear and good there is nothing here which adds at all to our knowledge on the subject, and the most attractive features are rather those dealing with general arrangement and matters of this kind. Two small slips were noticed, one on p. 23 where the author maintains, quite erroneously, that as the stress in a beam varies as the distance from the neutral axis the proper section for a beam is one where the width varies uniformly from a maximum at the two flanges to zero at a neutral axis. This is, of course, quite wrong, and it is always more economical to concentrate the available material as near the extreme top and bottom as possible.

On p. 86 dealing with angle covers; both the diagram and the text imply that the author believes angles to have tapered sides whereas in point of fact they are, of course, parallel. These little mistakes do not, however, in the slightest detract from the general usefulness of the book, and we think it will be appreciated by students leaving college who are likely to be largely engaged in the design of plate girder bridges, particularly for railways.

**Slide Rules and How to Use them. By Thos. Jackson, M.I.Mech.E.**
London: Chapman & Hall, Ltd. 30 pp. demy 8vo. 1s. 6d. net.

This little book consists in an explanation of the principle of the slide rule and the manner in which it is used and describes the leading forms of rules in the market.

The explanations given are clear and the book can be recommended to those who possess a slide rule and do not know how to use it.

In our opinion the book would be improved by a clear but elementary explanation of the logarithmic principle; we think that people who are quite familiar with logarithms hardly need a book to learn how to use a slide rule.

An interesting feature of the book is an explanation of the meaning of the various special markings nearly always to be found on slide rules; with the exception of π we think that slide rules would be better without these markings.

Description is given of various fancy slide rules—the "log-log" and the like; these rules are interesting but the writer prefers a rule in which there are as few scales as possible and he thinks that most users of rules hardly ever use the special scales even if they have them.

We do not notice in the book any description of the interesting Tavernier-Gravet slide rule.

**The Chemical Analysis of Steel Works Materials. By Fred Ibbotson, B.Sc., F.I.C.**
London: Longmans, Green & Co. Price 21s.

This is a very complete treatise on the chemical analysis of the materials which are dealt with in the laboratory of a steel works, and is written by a chemist who has himself done much to improve analytical methods, especially as applied to the more complex steels. Mr. Ibbotson may be safely followed as a guide in this branch of analysis, which interests many others besides steelmakers, on account of the increasing use of high tensile steel for structural purposes. The chapters which approach most closely to the work of the concrete engineer, however, are those which deal with the analysis of refractory materials, such as fire-clay, and of slags and cinders. The methods described are as simple as is consistent with accuracy, and will be found worth examination by the cement chemist. The closing chapters of the book describe the analysis of fuels, boiler waters and boiler scale. The treatise should be in every analyst's library.

# CORRESPONDENCE.

*Under this heading we invite correspondence.*

### The "Hume" Pipe.

*To the Editor of* CONCRETE AND CONSTRUCTIONAL ENGINEERING.

DEAR SIR,—As you are aware, it often happens that ingenious ideas in all branches of engineering work occur more or less simultaneously to persons who are perfect strangers to one another, and it is an everyday occurrence to find that inventions believed to be quite novel have been anticipated by previously granted letters patent.

An instance of this is furnished by the interesting process for concrete pipe making described in your issue of September last, and there characterized as an entirely new method of producing pipes by placing concrete in a metal mould, rotating the latter with sufficient rapidity to develop centrifugal force, by which the concrete is distributed evenly throughout the mould forming a concrete wall of intense density.

Curiously enough, this identical process was patented in England as far back as 1903 (about seven years before the date of the Hume patent) by Monsieur François Hennebique, and was worked for some time in France. In those days, however, the price of iron and steel pipes was such as to make it difficult to compete against them in respect of cost. Conditions have altered considerably since then, and rendered practicable the application of the process on a large scale.

In order that your readers may have an opportunity of comparing the account given by you of the Hume patent with the description and claim embodied in the Hennebique patent of 1903, I give the following particulars from the latter document :—

" The invention consists essentially in charging the cement beton or other like substance capable of agglomeration, in a pasty state into a metal or like pipe, the internal surface of which is cylindrical when it is a question of producing a pipe, or corresponds to the reliefs of the column or shaped casing which is to be obtained, such moulding pipe being partially or totally closed at both ends by plates, discs or covers which may be mounted on a spindle. The mould thus prepared is then given a somewhat rapid rotary motion about its axis, the material (cement beton for instance) owing to centrifugal force is forced violently into concentric layers against the internal surface of the moulding pipe, the form of which it assumes. The substances arrange themselves first in the order of their respective specific gravities from the periphery towards the centre, water and air being thus naturally eliminated.

At the end of a suitable period of rotation, more or less prolonged according to the nature of the materials employed, the material is allowed to set, and then the hollow column or finished pipe may be removed from the mould."

The claim made at the end of the Hennebique patent runs as follows :—

" A process or method of making pipes, conduits, columns, casings or sheaths of cement beton or other like agglomerate, strengthened or not with metal rods and the like, said process consisting in charging the said beton or agglomerate into a tubular metallic or other receptacle, the internal surface of which has the form of the external surface of the pipe or sleeve to be obtained, in closing the ends of the receptacle (after the foundation or lining of metal rods has been previously embedded in case the pipes to be made are formed of strengthened beton), and in then subjecting this receptacle to a rotary movement, which under the action of centrifugal force uniformly moulds and compresses the material placed in the interior against the surface of the mould and expels water and air substantially as described."

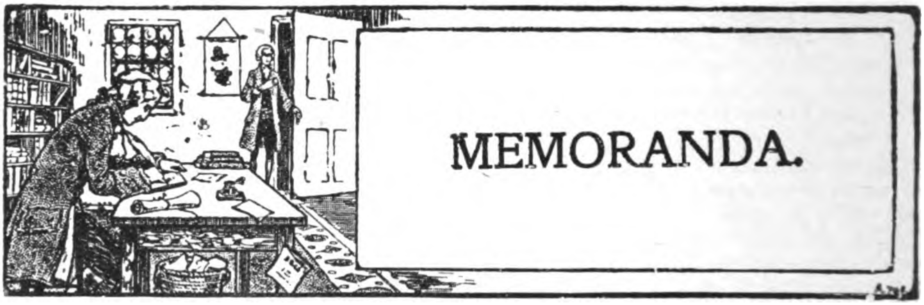
By turning to page 640 of your current volume, readers can readily see for themselves that the words used in your description of the Hume patent are practically the same as those employed seventeen years ago by François Hennebique. Your readers will also see that the Hume process follows in every detail the anterior method invented by M. Hennebique, who thus adds one more claim to be regarded as the pioneer of modern reinforced concrete construction.

Yours faithfully,

W. NOBLE TWELVETREES.

P.S.—Since writing the above, I have learned that for the past fifteen months a factory has been at work in France producing concrete pipes on practically the same principle as that described above, the owners of the establishment being quite unaware of either the Hennebique or the Hume patent.

W. N. T.



# MEMORANDA.

*Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.*

**Building in Concrete by Unskilled Labour.**—The simplicity of concrete block construction for small buildings is being taken advantage of at Copmanthorpe (Yorks), where the members of the local Y.M.C.A. are building a new club house and institute by their own efforts. The building, which has been designed by Mr. E. Ridsdale Tate, architect, is of the bungalow type, and contains a main hall, 60 feet by 20 feet, with a stage, and an annexe 40 feet by 12 feet. The walls are being built of hollow concrete blocks, and the roof is to be tiled. All the labour engaged on the work is voluntary. The blocks are being moulded without the aid of machinery in a disused aeroplane hangar during the evenings, by the aid of electric light.

Owing to the scarcity of skilled labour the Annfield Plain Urban District Council has decided to carry out its housing scheme at Dipton with concrete blocks, instead of stone, as was at first contemplated.

**Large Room without Columns.**—It is reported in the *American Architect* that the largest room without columns is said to be in a solid concrete building of the Lucknow Mosque, India. The room is 162 ft. long, 54 ft. wide, and 53 ft. high. The timber mould was left a year for the concrete to set, and the building, 125 years old, is still unimpaired.

**Interlocking Building Blocks.**—Building blocks of concrete, tile, or other suitable material are being made so as to interlock by a V-shaped formation of their top and bottom surfaces. These V-shaped grooves are arranged in herringbone order, at a 45° angle, and the special unit used at corners has the axis of the herring bone design running transversely on one-half the surface, and longitudinally on the other half.

**The Dagenham Garden City.**—At a recent meeting of the London County Council the Housing Committee reported that arrangements were being made, as authorized by the Council, for the construction of concrete houses on the Dagenham site in accordance with plans already approved. In addition to these approved houses, the Committee had considered simpler methods of concrete house construction with a view to the elimination of as much skilled labour as practicable and more rapid erection, but had come to the conclusion that certain of these more simply constructed houses did not appear to fulfil the standards set up by the Council. The Committee had been advised that, providing satisfactory arrangements could be made with the building trades, a maximum amount of unskilled labour could be employed, under the supervision of skilled men, on the types of concrete houses already approved. Subject to sufficient supplies of cement being available, it was possible to employ a considerable amount of unskilled labour at once at Dagenham in the manufacture of concrete blocks.

**Tiverton Housing Scheme.**—Owing to the delay in the delivery of bricks, the Tiverton Town Council is considering alternative methods of construction in connection with its housing scheme. There is a good supply of aggregate in the district, and some satisfactory sample concrete blocks have been made.

**New Reinforced Galleries at Chester.**—At Chester new reinforced concrete galleries, three storeys high, have been erected from the designs of Mr. W. Beswick, A.R.I.B.A., for Messrs. Brown & Co., Ltd.

## NEW METHODS AND MATERIALS.

The following is a further list of materials and new methods of construction approved by the Standardization and Construction Committee, up to November 8 :—

*Henry Addison, 27, Bilberry Road, Eltham, S.E. 9.*—A system of concrete construction ; the walls are composed of reinforced slabs with projecting ribs meeting together in centre of wall and forming a cavity ; these slabs are gripped and held in position by grooved pillars which are bolted to the wall-plates. All the sections are pre-cast, reinforced and grouted together, forming a solid structure.

*W. Scotter Owen, 121, Cannon Street, E.C. 2.—The "Lo Rona" System.*—The stancheons are formed of concrete cast *in situ* as the work proceeds and have short lengths of projecting steel rods cast into the concrete lintel and base. The slabs are pre-cast with a grooved edge all round, and when in position the vertical cavity is filled with liquid grout, and transverse iron cramps are dropped into the vertical hollows. The horizontal grooves are filled with cement mortar. At the first floor and roof levels concrete lintels are formed *in situ*, reinforced with iron bars as required for the span between stancheons.

*Kieffer & Fleming, 83, Pall Mall, S.W. 1.—The "Bur-pal" Building System.*—This is a standardized method of timber framed construction, each part being cut to exact dimensions and assembled on the site. After erection, the framework is covered with metal lathing and finished with "Gunite."

*T. Gibson, 33, Beech Grove, Whitley Bay, Northumberland.*—The "*Stanslab*" system of concrete construction consists of pre-cast stancheons and slabs interlocking. The stancheons are so constructed as to allow a continuous cavity through the walls.

*The Universal Housing Company, Ltd., Rickmansworth, Herts.*—The "*Universal*" system of construction consists of standardized outside wall, partition, ceiling and roof timber units, reinforced with steel strips, manufactured in interchangeable sections and covered with asbestos cement sheeting at the factory. The framing is spaced at about 7 in. centres, whereby risk of damage to the sheeting is minimized.

*D. C. Fidler, Engineer and Surveyor, Hayes, Middlesex.*—This system is a combination of slabs and poured concrete. Upon the damp-proof course pre-cast clinker blocks are laid to break joint and are set apart to form a cavity of a width according to the thickness of the wall to be produced. The slabs or blocks are secured together by patent wall ties extending at intervals across the cavity. The cavity is filled with semi-liquid concrete up to within, say, 4 in. from the top of the slabs as each course is laid. By this method all through joints are prevented and the semi-liquid concrete keys the whole wall into one homogeneous mass.

*Dawson & Jones, May Hill, Swansea.*—In this system the corner and intermediate piers are first erected, either *in situ* or made in blocks and built afterwards. These piers have projecting ribs of the thickness required for the walls, and to these the shuttering is bolted. The bolts are put through gas tube sleeves which form spacing pieces for the shuttering and keep the wall an even thickness ; these sleeves remain in the concrete and when the bolts are withdrawn no damage to wall occurs.

*The Chemical and Technical Syndicate, Ltd., 287, Regent Street, W.—"Cesalith" Concrete Building Block.*—The block is interlocking and is of semi-hollow construction, each space being partitioned and isolated. Size of block, 18 in. by 9 in. by 9 in.

*The Strenic Construction Company, Corsham, Wilts.*—The "*Strenic*" Block is a concrete block, the aggregate being of broken stone, finished with a stone face.

## TRADE NOTES.

**Reinforced Concrete in Australia.**—We are asked to state that the sole representation in Australia for the Considère Construction Co., of 5, Victoria Street, Westminster, has been given to Messrs. McLean and Morris, Atlas Buildings, 8, Spring Street, Sydney, who will be glad to furnish information to readers and others interested in Australasia.

**Reinforced Concrete in the Argentine.**—Our readers will recollect that prior to the War large contracts had been let out at Buenos Aires for improvements in the port and docks, most of this work to be carried out in reinforced concrete. This work was resumed about three months ago. Messrs. C. H. Walker & Co. of Westminster are the contractors, and Messrs. Lindsay Son & Henderson, the general engineers. Messrs. Edmond Coignet, Ltd., are acting as the specialist engineers for the whole of the reinforced concrete work. The whole amount of the contract, including concrete and masonry, amounts to £5,500,000.

**Forrester-Marsh Patents,** 11 Cork Street, London, W.1.—"A new system of Metal Shuttering which applies to all forms of reinforced concrete construction, and particularly to the economical erection of monolithic continuous cavity walls in one operation." The rights for operating these patents in Great Britain having been disposed of to an influential London Group, enquiries are now invited from Builders, Contractors, Public Bodies, Financiers, etc., etc., for the foreign rights. Amongst others, France, Belgium, Switzerland, Holland and U.S.A. are still available.

## TENDERS ACCEPTED.

### Concrete Houses.

BERWICK.—The Berwick Town Council has accepted the tender of Mr. Stephen Easten, of Newcastle-on-Tyne, for the erection of sixty-eight concrete houses—Type "A" houses at £969 each, and Type "B" houses at £1,091 each.

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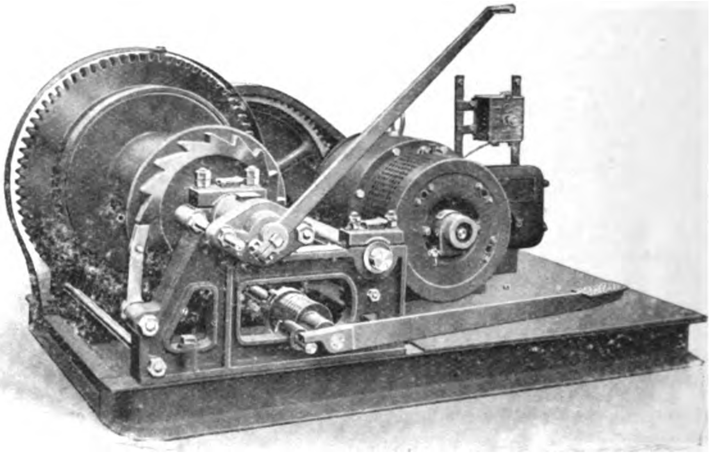

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CHESTER.—The Chester Rural District Council has accepted the tender of the Seacroft Concrete Co. for the erection of thirty-six concrete houses at Christleton, at a cost of £35,751, exclusive of road making. The Chairman of the Housing Committee stated that this system of construction would effect a saving of £150 per house as compared with ordinary methods.

CLOWNE.—The Clowne Rural District Council has accepted the tender of Messrs. Roker & Sons, of Sheffield, for the erection of houses at Clowne and Creswell, at £880 per house for all brick houses and £857 for houses with brick and concrete walls.

LANCASHIRE.—The Lancashire County Council has accepted the tender of Messrs. J. Parkinson & Sons (Blackpool), Ltd., for the erection of 250 concrete cottages in connection with its housing scheme.

RUTHERGLEN.—The tender of Messrs. W. Miller & Co., at £3,681, has been accepted by the Rutherglen Town Council for the plaster and concrete work on the local housing scheme.

TAMWORTH.—The Tamworth Town Council has provisionally accepted the tender of Messrs. Wilding & Wood for the erection of fifty concrete houses on the Wigginton Road site, at a cost of £790 10s. each.

WILLINGTON.—The Willington Urban District Council has awarded a contract to the Jefferies Construction Co. for the erection of the following concrete houses: twenty Type "A" houses at £892 10s. each; and fifty-eight Type "B" houses at £963 each.

## General.

GLASGOW.—A Special Committee of the Glasgow Corporation has recommended the purchase of a brick-making machine and concrete mixer, capable of turning out from 4,000 to 5,000 bricks per day, from the Lux Engineering Co., and a concrete block-making machine and mixer from the Winget Co. The total estimated cost of the plant, which is to be used in connection with the Corporation's housing scheme, is £2,014.

HUDDERSFIELD.—The tender of Messrs. J. Wimpenny & Co., of Spurn Point, Linthwaite, Huddersfield, has been accepted for the concrete work in connection with the erection of a concrete foundry, with an area of 2,000 sq. yds., at the Prest Royd Ironworks. Messrs. C. F. L. Horsfall & Son, of Lord Street Chambers, Halifax, are the architects.

LEEDS.—The Leeds Corporation has accepted the tender (on schedule prices) of Messrs. A. Mitchell, Ltd., 6, South Parade, Leeds, for the provision of concrete fence posts, wiring and ironwork on the various housing sites of the Corporation.

NEWARK.—The Nottinghamshire County Council has accepted the tender of Messrs. Walter Scott & Middleton, Ltd., 28, Victoria Street, London, for the erection of a concrete bridge (on the Hennebique system) and contingent works, over the River Trent at Muskham, near Newark, at £47,224 12s. 1d. Other tenderers were R. J. May (Norwich), Lambrick & Co. (Burton-on-Trent), Holloway Bros. (London), S. A. Pillatt & Son (Nottingham), McBride & Gray, Ltd. (Glasgow), Yorkshire Hennebique Contracting Co., Ltd. (Leeds), Brims & Co., Ltd. (Newcastle-on-Tyne), and T. Rowbotham (Birmingham).

STRETFORD.—The Stretford Urban District Council has accepted the tender of Messrs. W. Thorpe & Sons for laying reinforced concrete pipes at the Trafford Power Station, for the sum of £855.

WANDSWORTH.—The Wandsworth Borough Council has accepted the tenders of the Cement Marketing Company for the supply of Portland cement at £4 7s. 6d. per ton, and of Messrs. Dawson & Co., at £4 10s. 6d. per ton.

## TENDERS INVITED.

BRIERFIELD.—The Brierfield Urban District Council invites tenders for the erection of fifty houses at Bent Head. Plans, etc., from the Architects, Messrs. Adshead & Topham, 23, King Street, Manchester. Deposit, £10. Sending-in day, December 18.

CHELTENHAM.—The Housing Committee of the Cheltenham Corporation invites tenders for the erection of forty houses of brick or concrete block construction on the St. Mark's housing estate. Plans and specifications from the Architects, Messrs. Chatters, Smithson & Rainger, Regent Street, Cheltenham. Deposit, £2 2s. Sending-in day, December 18.

CHIPPING SODBURY.—The Chipping Sodbury Rural District Council invites tenders for the erection of six houses at Badminton and eight at Hawkesbury Upton. Plans, etc., from the Housing Architect, R.D.C. Offices, Chipping Sodbury. Sending-in day, December 20th.

CLUTTON.—The Clutton Rural District Council invites tenders for the erection of six houses. Plans etc., from the Architects, Messrs. Petter & Warren, 74, Henford, Yeovil. Sending-in day, December 21st.

DUBLIN.—The Dublin Corporation invites tenders for the supply and erection of plant for the manufacture of road material, including asphaltic concrete. Tenders to be sent to Mr. Patrick Tobin, Secretary, Paving Committee, City Hall, Dublin, by January 4, 1921.

LANGHOLM.—The Langholm Town Council invites tenders for the erection of ten blocks of two houses each. Plans, etc., from Mr. J. B. Gladstone, 100, High Street, Lockerbie. Deposit £2 2s. Sending-in day, December 14th.

LONDON (HACKNEY).—The Hackney Borough Council invites tenders for the erection of sixty-two maisonettes. Forms of tender, etc., from the Borough Engineer, Town Hall, Hackney. Sending-in day, December 15th.

MARPLE.—The Urban District Council of Marple invites tenders for the erection of fifty houses. Plans, etc., from Mr. D. J. Diver, U.D.C. Surveyor, Marple. Deposit, £1 1s. Sending-in day, December 20th.

MONMOUTHSHIRE.—The King Edward VII. Welsh National Memorial Association invites tenders for the erection of a hospital for consumptives at Pontypool Road, Monmouthshire. Plans and specifications from the Architects, Messrs. E. T. & E. S. Hall, 54, Bedford Square, London, W.C. Deposit, £5. Sending-in day, December 17.

SWINTON.—The Malton Rural District Council invites tenders for the erection of ten working-class houses at Swinton. Plans, specifications, etc., from Messrs. C. H. Channon & Son, Architects, Market Street, Malton. Deposit, £1 1s.

## PUBLICATIONS RECEIVED.

**City and Guilds of London Institute,** Department of Technology.—Programme 1920-21 Session. Publisher, John Murray, Albemarle Street, W.1. Price 2s. 6d. net.

**Wave Transmission Tools.**—A booklet on Wave Power Tools, designed by Messrs. W. H. Dorman Co., Ltd., of Stafford, with a short introductory note on Power Transmission by Waves, by Mr. Walter Haddon.

## RECENT PATENT APPLICATIONS.

135,471.—H. E. Hagen & J. Kjolsrud: Reinforced concrete poles.
138,332.—L. H. Guimonneau: Wall construction.
149,988.—R. Boveroulle: Manufacture of cement from slag.
151,331.—J. Woolcock: Floor construction.
151,392.—J. Wild: Roof principals.
151,441.—A. F. Jefferies: Floor and ceiling construction.
151,442.—A. F. Jefferies: Building blocks.
151,531.—E. N. Goodlet: Vibrator for use in the mixing of concrete.
151,553.—A. S. Cox: Concrete slab roofs of curved construction.
151,692.—J. Woolcock & W. J. Stewart: Moulds for concrete blocks, panels and similar products.
151,750.—J. R. Baumann: Building blocks.
151,755.—A. Hardie: Cavity walls built with concrete blocks and wall ties.
151,765.—A. Hardie: Concrete columns.
151,808.—A. & F. Blundell: Slabs, blocks, etc., for building and paving.
152,106.—R. W. Leesley: Use of low-grade carboniferous material in the manufacture of cement.
152,114.—Vickers, Ltd., & Sir G. T. Buckham: Concrete moulding machines.
152,160.—W. J. Stewart & J. Woolcox: Concrete floors.
152,173.—P. L. G. Johnston, R. R. G. Chisholm & W. A. Martin: Heat insulating concrete walls and ceilings.
152,241.—W. T. Rogers: Bonding building blocks.
152,397.—G. C. Royse: Reinforcement for concrete.
152,405.—J. Carter & W. Bennett: Building blocks.
152,701.—R. T. & R. W. Hunter: Construction of walls.
152,706.—T. Shepherd: Construction of walls.
152,708.—W. W. Love: Reinforced concrete slab building construction.
152,888.—W. E. & L. H. Hale: Concrete frame buildings.

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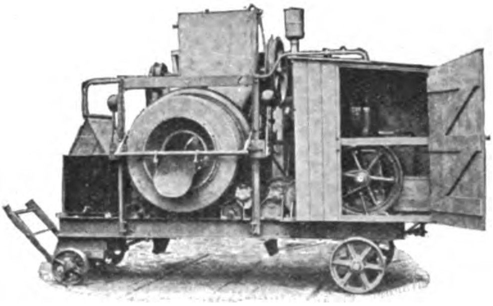

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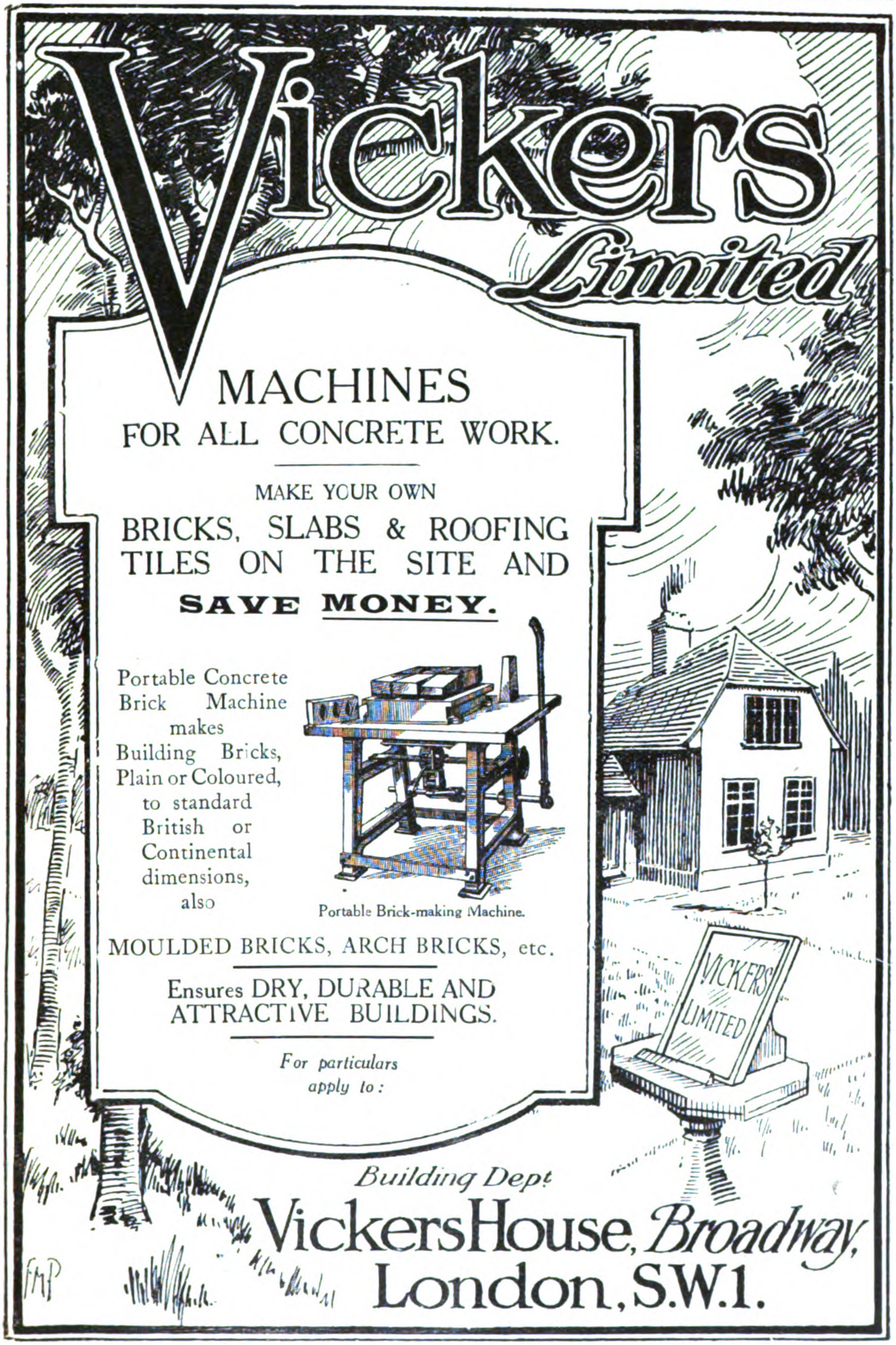

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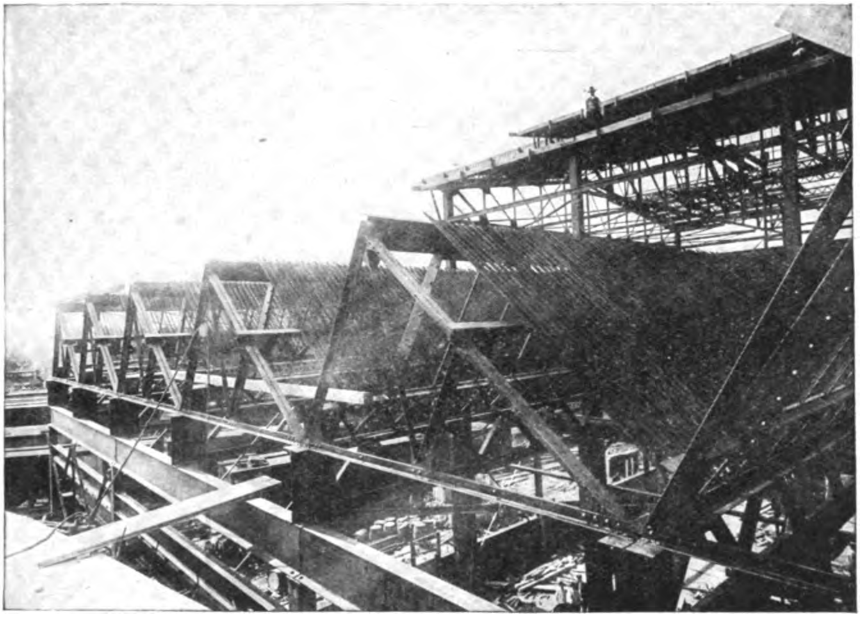

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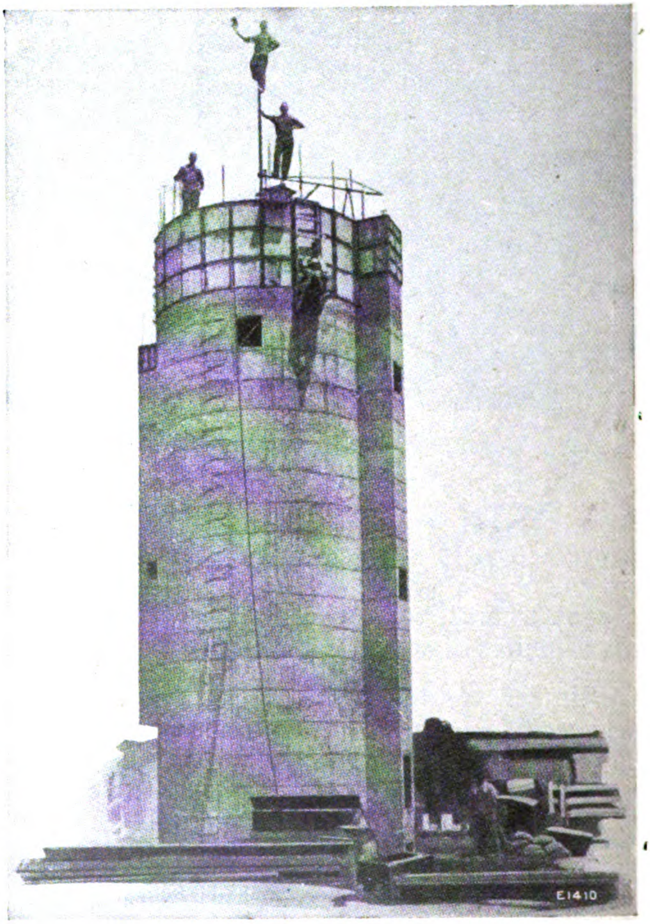

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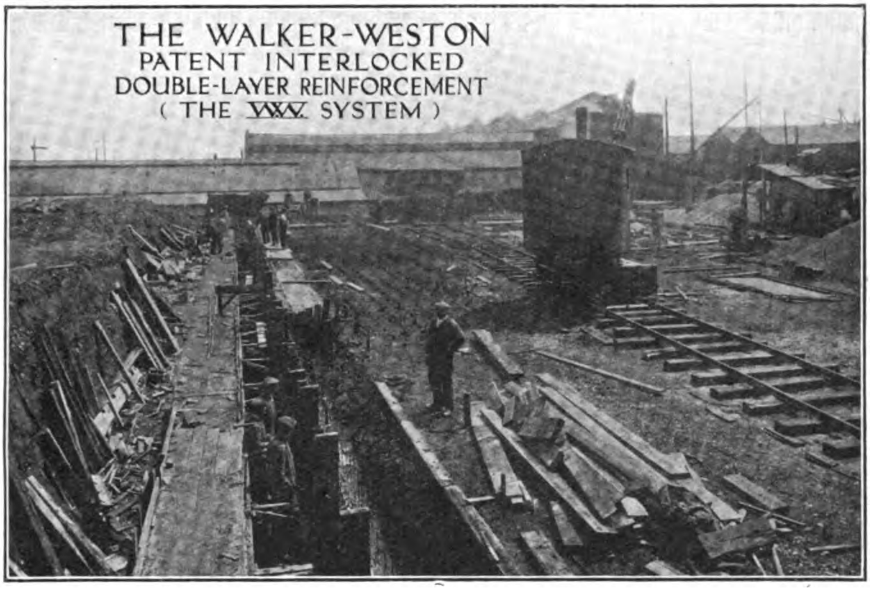

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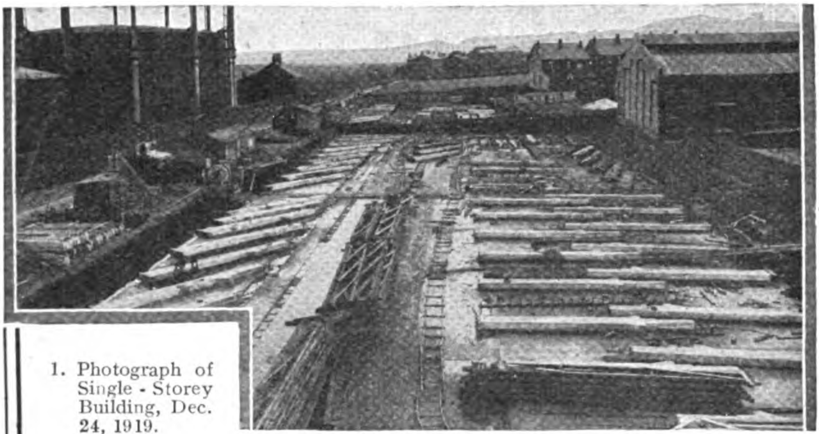

1. Photograph of Single - Storey Building, Dec. 24, 1919.

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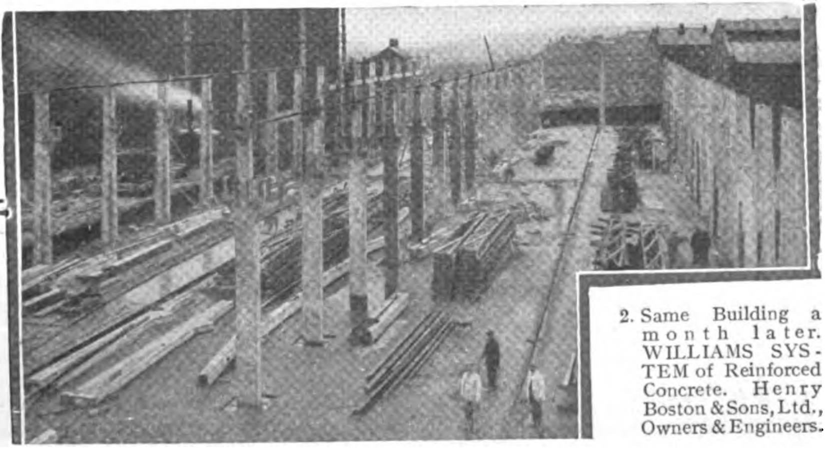

2. Same Building a month later. WILLIAMS SYSTEM of Reinforced Concrete. Henry Boston & Sons, Ltd., Owners & Engineers.

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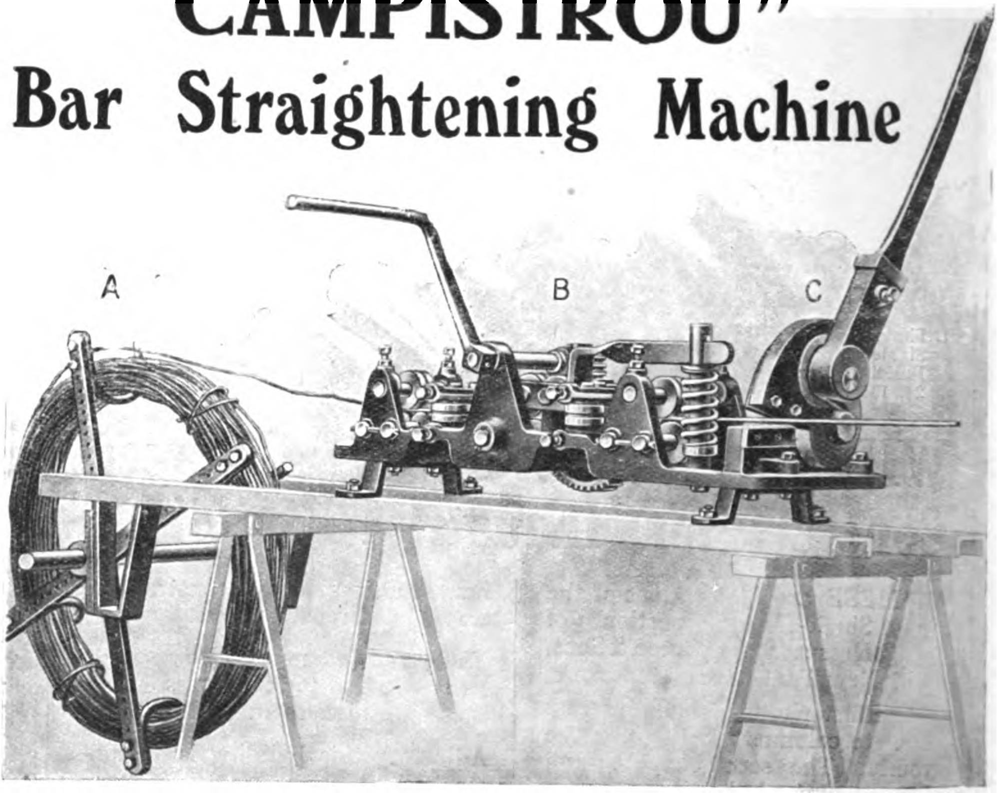

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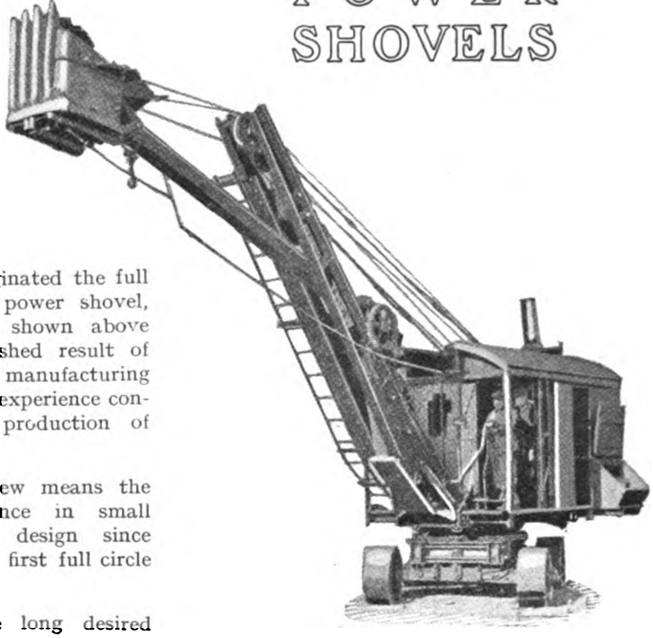

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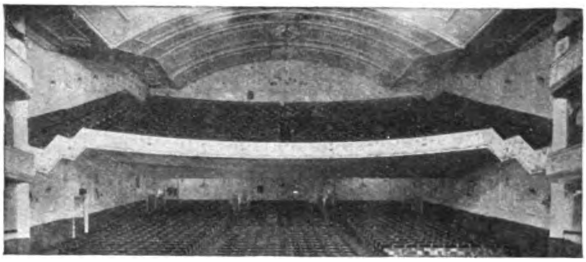

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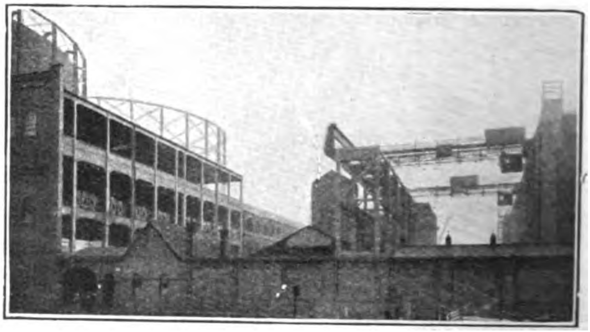

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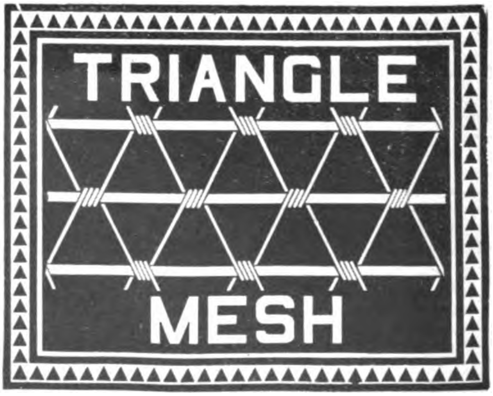

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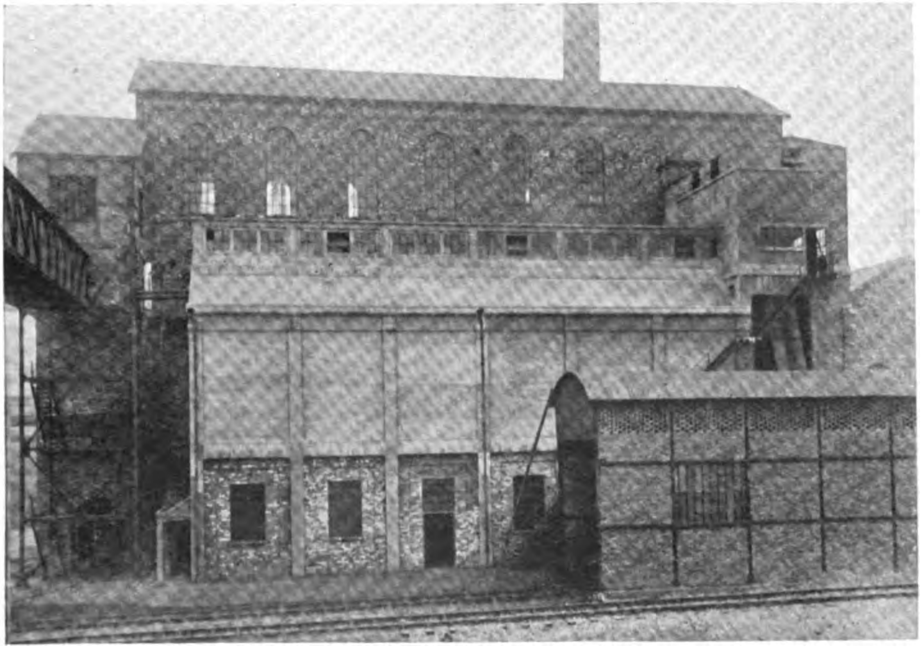

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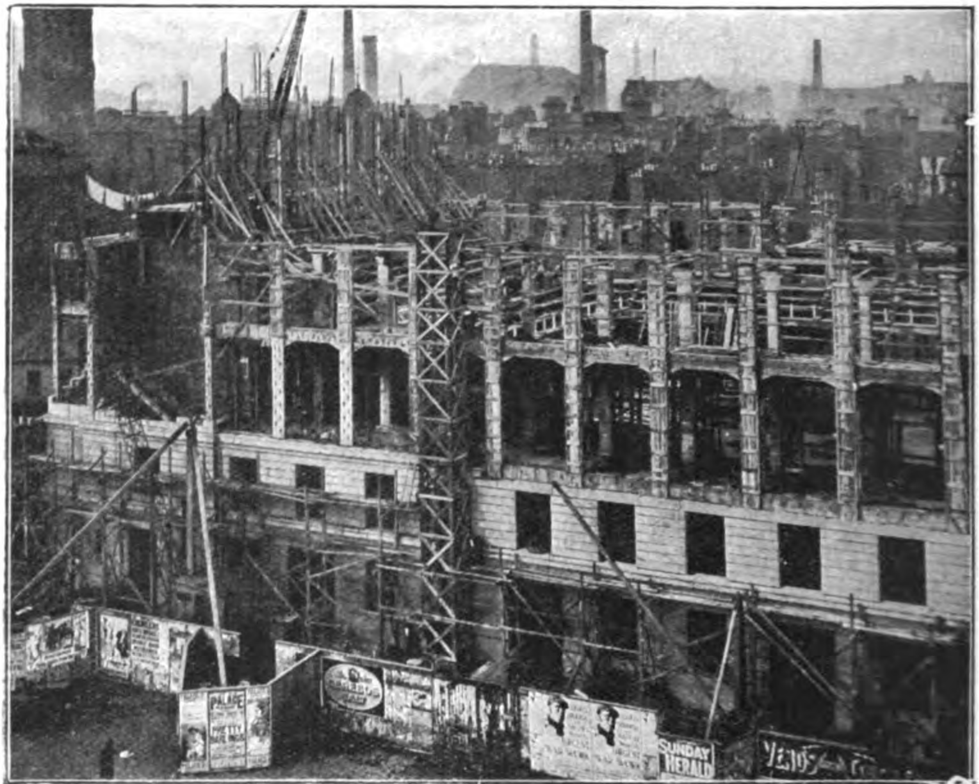

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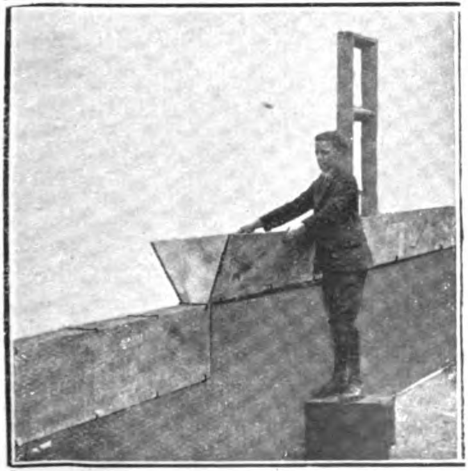

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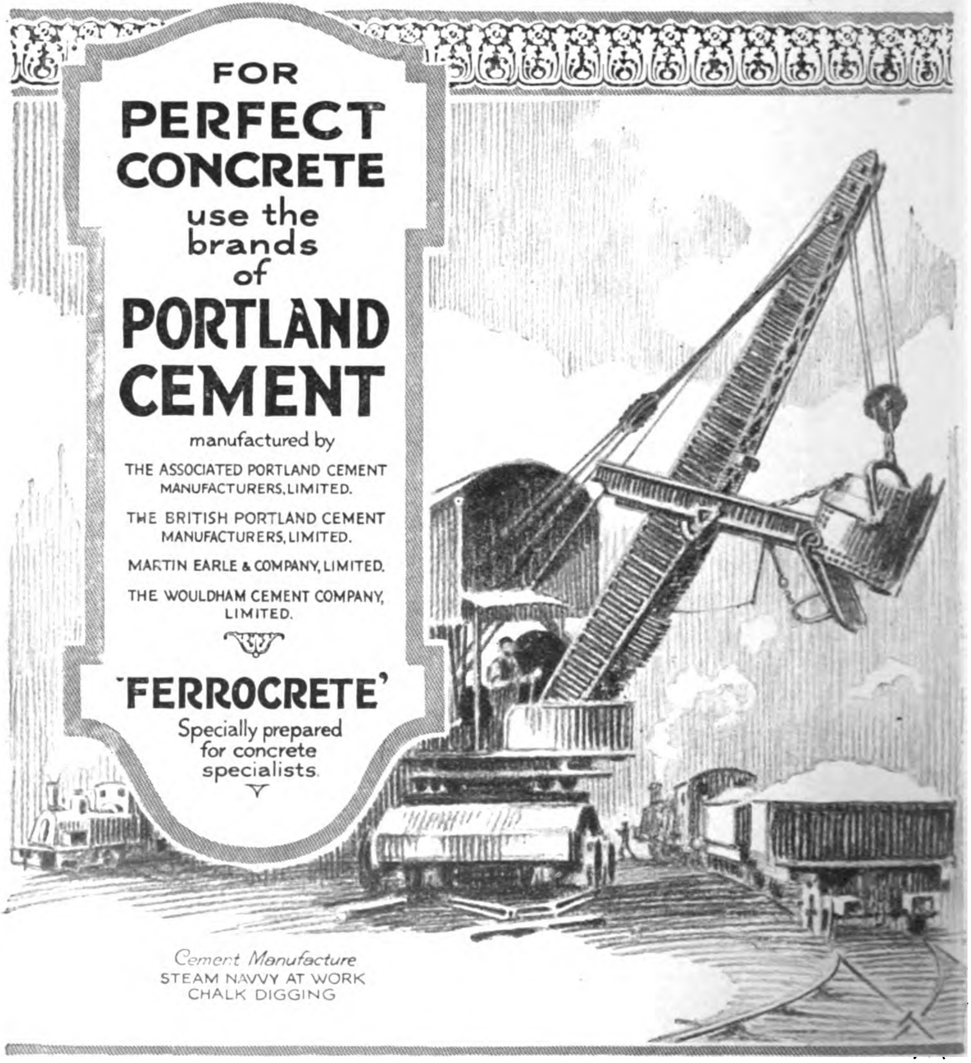

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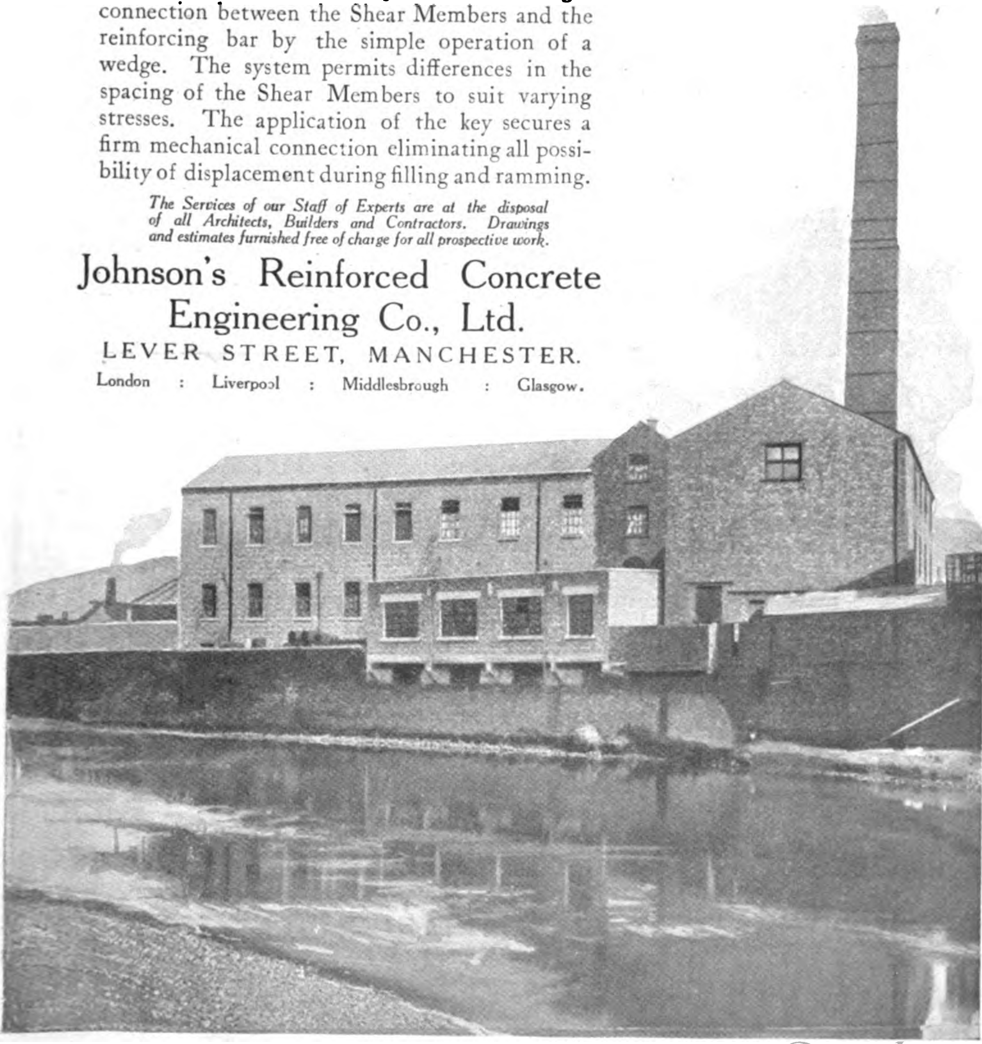

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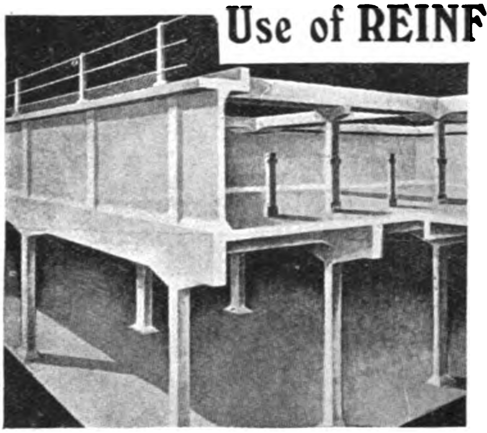

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# CONTENTS

Vol. XV. No. 12.
December, 1920.

PAGE

EDITORIALS .. .. .. .. .. .. .. .. .. .. .. 787

NEW REINFORCED CONCRETE MILL AT HECKMONDWIKE—COKE BUNKERS FOR THE NORTHAMPTON GAS-LIGHT COMPANY .. .. .. .. .. .. .. 789

MAXIMUM STRESSES IN SHORT CIRCULAR COLUMNS OF MASONRY, ECCENTRICALLY LOADED 793
By R. E. STRADLING, M.C., B.Sc., etc. (Lecturer in Civil Engineering, University of Birmingham).

THE CONCRETE INSTITUTE .. .. .. .. .. .. .. .. .. 804
Monthly Notes, by THE SECRETARY. The Presidential Address by E. FIANDER ETCHELLS, A.M.Inst.C.E., etc.

CONCRETE COTTAGE BUILDING .. .. .. .. .. .. .. .. .. 809
Cottages at Brockley.

CONCRETE ROAD CONSTRUCTION.. .. .. .. .. .. .. .. .. 818
Abergavenny and Brecon Main Road, South Wales—Longhoughton Road, Northumberland.

CONCRETING IN COLD WEATHER .. .. .. .. .. .. .. .. 821

RECENT BRITISH PATENTS RELATING TO CONCRETE .. .. .. .. .. 823

CONCRETE IN THEORY AND PRACTICE: REINFORCED CONCRETE SIMPLY EXPLAINED .. 831
By OSCAR FABER, O.B.E., D.Sc.

CEMENT NOTES .. .. .. .. .. .. .. .. .. .. .. 834

TEST OF A CONCRETE FLOOR ARCH .. .. .. .. .. .. .. .. 836

NEW METHODS OF CONSTRUCTION .. .. .. .. .. .. .. .. 839

NEW CONCRETE MACHINERY .. .. .. .. .. .. .. .. .. 842

NEW BOOKS .. .. .. .. .. .. .. .. .. .. .. 844

CORRESPONDENCE .. .. .. .. .. .. .. .. .. .. .. 845

MEMORANDA .. .. .. .. .. .. .. .. .. .. .. 846

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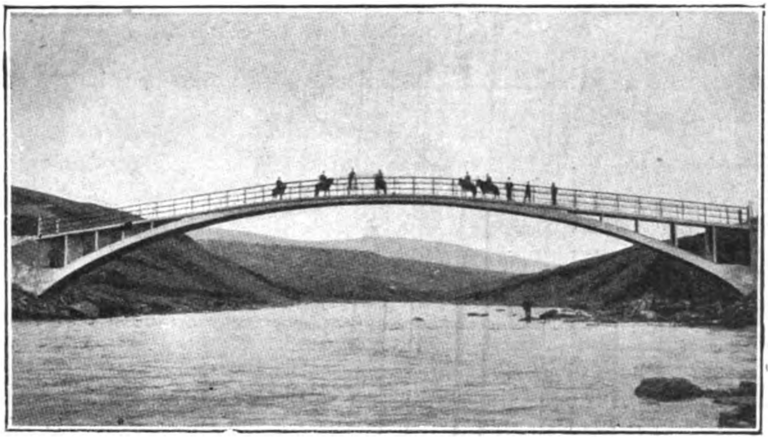

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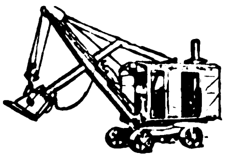

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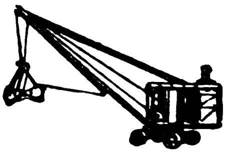

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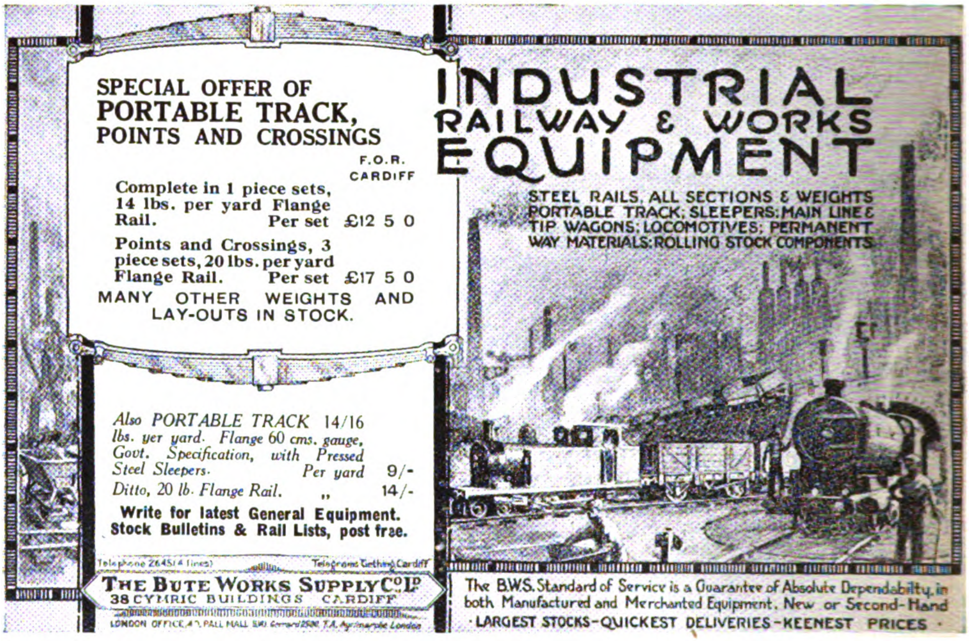

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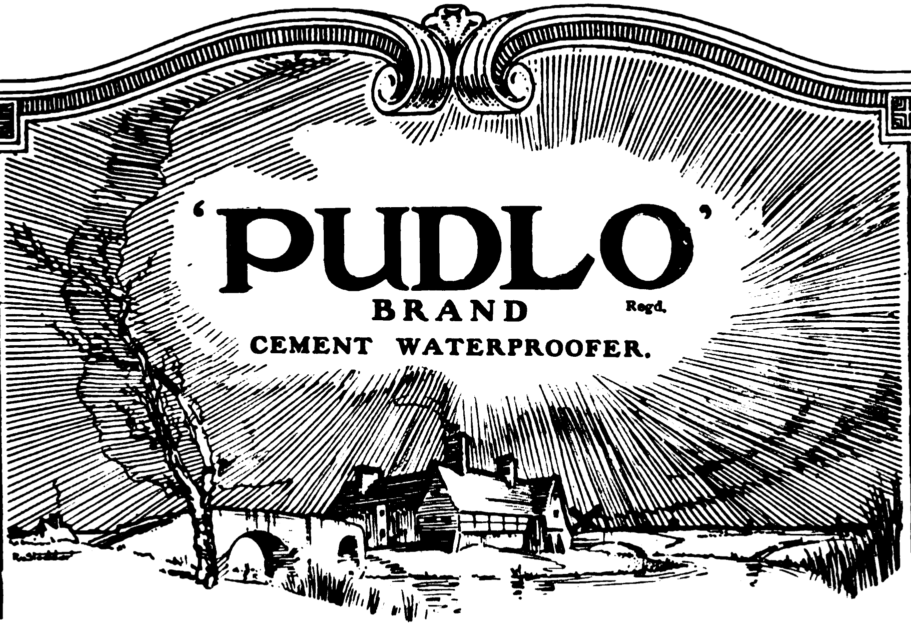

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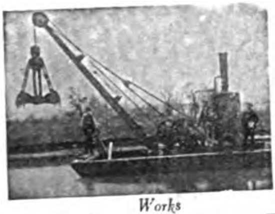

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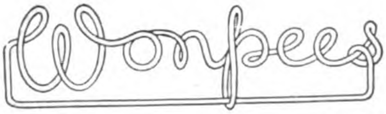

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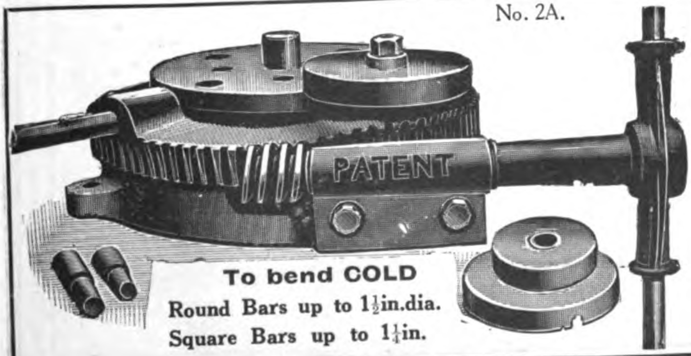

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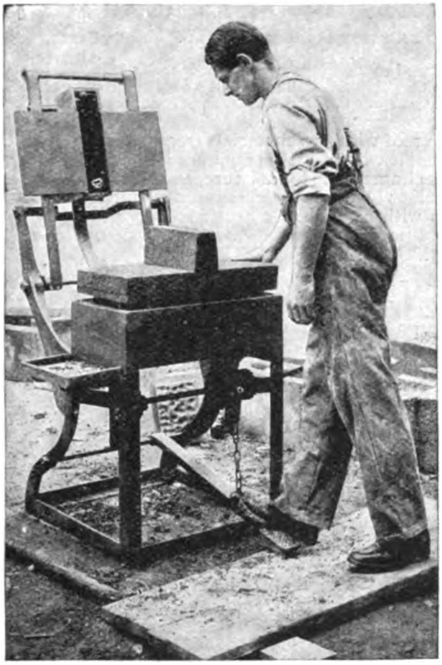

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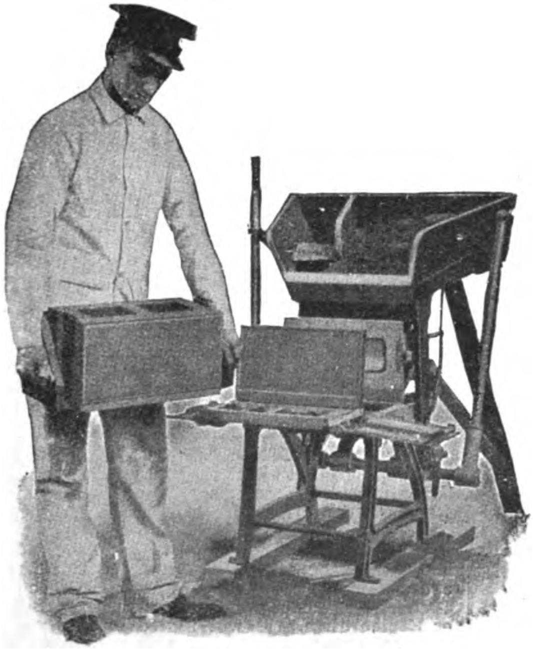

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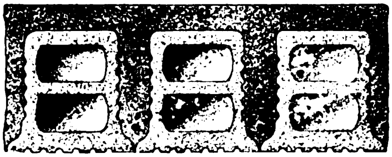

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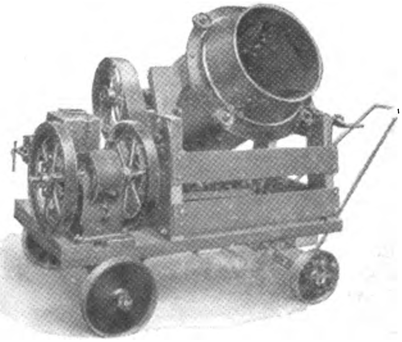

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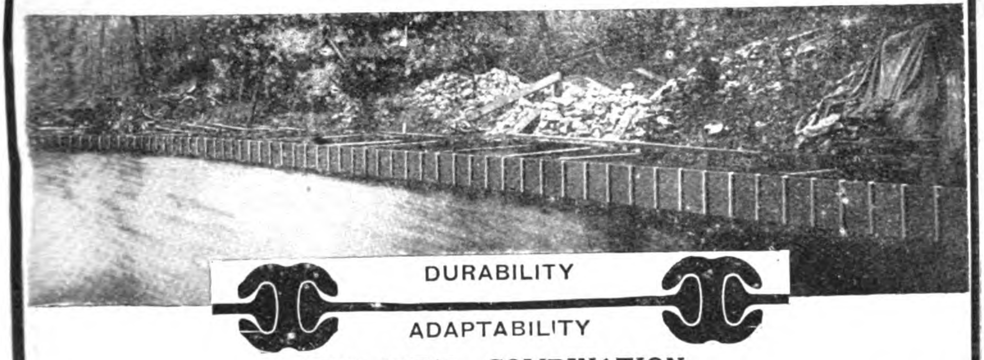

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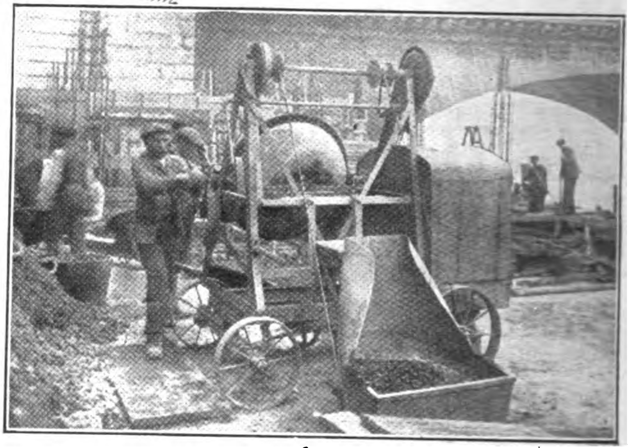
## INDEX TO ADVERTISERS

| | PAGE |
|---|---|
| Allied Machinery Co., Ltd. | ix |
| Associated Portland Cement Manufacturers, Ltd. | xiv |
| Australia Patent Block Machine Co | xxvii |
| Barb Engineering Co. | xxv |
| Boyer, Wm. & Sons | xxv |
| British Portland Cement Manufacturers, Ltd. | xiv |
| British Reinforced Concrete Engineering Co., Ltd. | xxvi |
| British Steel Piling Co. | 848 |
| Building Products Ltd. | Cover |
| Bute Works Supply Co., Ltd. | xx |
| Byrd, A. A., & Co. | iv |
| Cement Marketing Co. | xiv |
| Chalmers-Edina Co. | xxviii |
| Christiani & Neilsen | xvii |
| Climbing Steel Shuttering Co. | xiii |
| Coignet, Edmond, Ltd. | xx |
| Concrete Utilities Bureau | — |
| Considère Construction Co., Ltd. | vi |
| Coppee Co. (Great Britain), Ltd. | xi |
| Cyclops Concrete Co. | xxviii |
| Earle, G. & T., Ltd. | Cover |
| Harris Bros. | xii |
| Helical Bar & Engineering Co. | viii |
| Holst, K., & Co. | xiii |
| Indented Bar and Concrete Engineering Co., Ltd. | x |
| Johnson's Reinforced Concrete Engineering Co., Ltd. | xv |
| Jones, W. & Sons | xvi |
| Kennedy, W. | xxv |
| Kerner-Greenwood & Co., Ltd. | xxiii |
| Leeds Oil & Grease Co., Ltd. | xxv |
| London Phosphate Syndicate, Ltd. | xxviii |
| Martin Earle & Co., Ltd. | xiv |
| McGraw-Hill Publishing Co., Ltd. | xxiv |
| Millars' Timber & Trading Co., Ltd. | xxx |
| Moler Fireproof Brick and Partition Co., Ltd. | xxviii |
| Muirhead, Macdonald Wilson & Co., Ltd. | xviii |
| Ransome-verMehr Machinery Co., Ltd. | xxii |
| Self-Sentering Expanded Metal Works, Ltd. | iii |
| Side Groove Steel Piling Supply Co., Ltd. | xxix |
| South Wales Portland Cement and Lime Co., Ltd. | ii |
| Stone Court Chalk, Land & Pier Co., Ltd. | Cover |
| Stothert & Pitt | 850 |
| Super Cement Ltd. | xxiv |
| Trussed Concrete Steel Co., Ltd. | xix |
| Vickers, Ltd. | i |
| Walker-Weston Co., Ltd. | v |
| Williams Structures, Ltd. | vii |
| Wouldham Cement Co., Ltd. | xiv |
| Wylie, Matthew & Co. | xxvii |
| Yorkshire Hennebique Contracting Co., Ltd. | xii |



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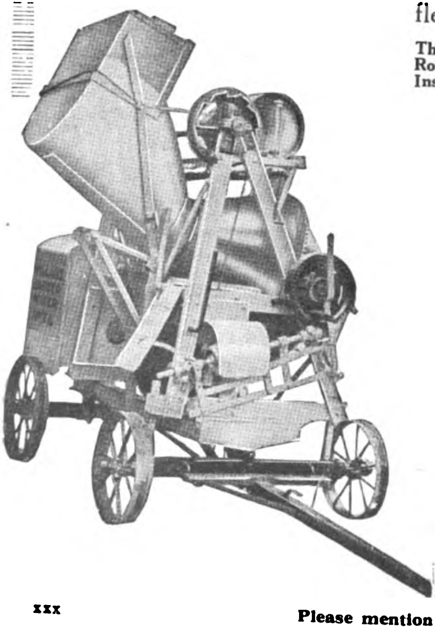

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